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PHYSICAL GEOGRAPHY VERSUS GENERAL SCIENCE.[1]

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As you all know there is a very important movement now in progress looking toward the re-valuation of many high school studies as well as the introduction of new ones. We are met here to-day for the discussion of one phase of this movement which concerns the introduction of a course in general science, elementary science it is sometimes called, and the relation of this proposed new course to physical geography.

After a long and careful analysis of the situation from all standpoints it seems to me that the proposed course in general science for the first year of the high school is fundamentally bad and a decidedly backward step. If generally introduced it will displace physical geography which I hope to be able to show you is, when properly interpreted, the only science study which is fully adapted to this stage of the school course.

It has been some years since the report of the Committee of Ten which resulted in the inauguration of a new departure in physical geography teaching. To many the results do not seem to fulfill the expectations and they have been casting about for something which shall better serve as an introduction to formal science in the later years of the high school course. In California as in other parts of the country there are those who for a long time have been advocating a course combining the elements of the various sciences for the first year, and this idea has at last found actual expression.

It is with the hope of discouraging this movement, and saving the high schools years of groping in the darkness of this general science notion, that I wish to plead the advantages from every standpoint of this old but too often unappreciated subject of

[1] Read before the California State Teachers' Association, Dec., 1909.

physical geography. Because of wrong ideas as to what physical geography should be for first year high school pupils, because of the wrong attitude of most of the texts, because of the wrong conceptions of laboratory work, and the too formal demands of college entrance requirements, and finally because of the still widely held view that anybody can teach physical geography whether he has had any preparation or not, the matter has reached such a stage that we have got to defend one of the most practical as well as broadly cultural subjects of the whole high school curriculum.

In the re-valuation of the high school studies the sciences in particular have come in for much criticism. It is said that their teaching is tinged too much by college requirements, that they are not practical, and as presented are not adapted to the needs of the high school period. To harmonize the formal science courses and give the necessary preparation for them the University of California is prepared to recommend a four years' course, of which the first year shall be general elementary science, the second year biology, the third year chemistry, and the fourth physics.

The proposal to place a general science course in the first year carries with it no direct or indirect reference to physical geography, and yet the relation between the two is so close that the question has got to be reckoned with. There is no room for both of them as a first year subject.

It will thus be seen that a discussion of the relation of physical geography to the proposed general science course is a pertinent one at the present time. The new movement has already carried general science into nearly twenty schools in California, displacing physical geography in a number of them. If the idea continues to spread it will affect physical geography much more seriously another year. Although we may hold that the conceptions behind general science are illogical and that the movement is ultimately destined to be a failure, yet we may be able to save a useless waste of time and strength by showing up its weak points in advance.

We have said that general science and geography are closely related. By this is meant the subject matter only. In treatment and viewpoint they are as far apart as the east is from the west. Geography contains the undifferentiated elements of science, and naturally comes before science. It is wonderfully inclusive both in breadth and depth, and while in its simpler aspects it is par-

ticularly adapted to immature minds which see things in their larger relations, it offers an unlimited field for study and investigation on the part of the advanced student.

As the child grows up and looks out over the world he sees various phenomena which constitute the raw materials of science as they occur in their natural relations. He becomes interested in them first as affecting his experiences. This is the geographic viewpoint. Later he becomes interested in an analysis of this orderly aggregate of phenomena, separates out related facts, such as are illustrated in the concrete sciences of physics, chemistry and biology. He is now studying science for its own sake.

If the pupil takes up the science method first he is specializing before he has obtained the proper perspective. He has missed the most broadly cultural, rational, and practical insight into nature offered by any study at any time throughout the whole high school course.

Now let us see what are some of the causes which have led to an attempt to substitute general science for the broad earth science of physical geography. Among these causes we might mention: (1) The complete ignorance of the meaning of the simplest physical phenomena on the part of pupils entering the high school. (2) A growing feeling on the part of many science teachers that in order to maintain the technical standard of their work, and satisfy university requirements, that an introductory science course is needed; and (3) A conviction on the part of many, due to a lack of knowledge of the possibilities of the subject, that physical geography, or physiography, cannot offer this preliminary training.

In discussing the first of the causes given above we may say that the offering of a course in elementary science in the first year of the high school is not the way to make up for the lack of science or nature study in the last years of the grammar school. The child should be introduced to elementary conceptions of nature before leaving the grammar school, and we must insist upon the work being done there. If the high school should offer certain courses which ought to be given in the grades, that makes it all the more difficult for us to get them introduced where they belong. As conditions are at present, perhaps one third of eighth grade pupils never enter the high school, but go out into the active duties of life completely ignorant of the simplest physical, chemical, and biological facts illustrated in the phenomena of everyday experience. It is essential from the

standpoint of the grammar school that some form of elementary science, or as I would prefer to call it, nature study, be given before the end of the eighth grade. Then the pupils who go no farther have some preparation for life, and those who continue have their interest awakened with the acquirement of some simple notions of things which form the basis of real science. The treatment of this problem in the grammar school should be essentially geographic, and along the same line as much of the material offered in physical geography.

As the matter stands at present, the lack of any science work in the grammar school is not a sufficient excuse for the introduction of an elementary science course in the first year of the high school. As a farther reason for the rejection of elementary science we already have well established in a large proportion of high school courses that broadly cultural earth science of physical geography. The latter contains all that is important in an elementary science course and from a far more natural point of view. There can be no denying the fact that the exponents of general science have underrated the possibilities of physical geography and have passed by the very thing needed to round out the elementary portion of the high school curriculum, and have taken up with a proposition which so far as yet tried out has proved a failure. The geography idea harmonizes and unifies the facts about us. It gives a definite setting to every problem taken up. It leads the student to see order and system in the complex phenomena of nature, and finally it trains them in right ways of judging and reasoning, and develops initiative. General science as it will be presented by most teachers will fail in every one of these particulars.

In regard to the supposed need of some science teachers, particularly those interested in physics, for a preliminary or introductory course, in order to maintain their advanced courses at a standard which shall satisfy university requirements, we may say that it is based on a wrong conception of the function of the high school. High school standards are as a rule too technical and university demands excessive. There is a rapidly growing sentiment among high school teachers that their work should be graded for the needs of this period rather than for the needs of an advanced school. This question is of especial importance because comparatively few ever reach the college or university. Mr. Carey of the Mission High School, San Francisco, has well said that we might with just as much reason introduce prelim-

inary courses in chemistry, biology, German, etc. When we look at the matter in the proper light there is absolutely no call for a preliminary course in any of these subjects, much less for a hodge podge course containing the elements of them all. The technical courses should, except perhaps in a few of the larger schools where there is a real demand for them and room for both technical and simple ones, all be made more elementary, concrete and practical.

Now with regard to the third reason for the introduction of general science, namely, the assumed failure of physical geography to give what is needed in the first year, we may say that it breaks down in the light of the foregoing discussion. The only criticisms which can have any strength against physical geography as a first year subject come partly from the results of poorly prepared teachers, and partly from a wrong conception current as to the fundamental basis of the subject. To the mind of the discriminating teacher who really understands the meaning of geography, these things should not bring it into disrepute. We may admit that in many cases teachers have been poorly prepared, but, may I ask, is the teaching of any high school science free from criticism? It is conceded on every hand that the sciences generally are presented in a too formal and abstract manner, but it is not proposed to drive them out of the curriculum for this reason. The doubts which have arisen in the minds of some as to the adaptability of physical geography to first year pupils are unquestionably due to the formal and abstract character of much of the class room and laboratory work. Notwithstanding the fact that the teaching of the subject is far from what we might wish, yet it is the general testimony that its materials appeal to and interest the pupils. This cannot be said of all the other sciences.

When we have cleared away the old notion that physical geography is a purely informational text-book subject, and have also gotten rid of the newer formal science aspect, which has served partly to obscure the practical culture side, I am thoroughly convinced we shall accept it as the only science which can with reason be placed in the first year of the high school course. It not only supplies introductory science notions, but gives them from a standpoint which is productive of the broadest and most intelligent conceptions of life and of the world about us.

We have not yet outgrown the notion that physical geography can be taught from a text-book, and so we often find it turned

over to the teacher that has the time for it without regard to his qualifications. In reality we should no more think of giving physical geography to a teacher without preparation than we would physics and chemistry.

The laboratory method in physical geography, although a step in advance of the old dependence upon a text-book, is in danger of becoming formal and lifeless. The importance of acquiring a rational knowledge of the interaction of the phenomena about us has often been lost sight of in weeks devoted to the study of contour maps, the prolonged analysis of weather maps, and the mechanical recording of physical observations. The ability to handle all sorts of meteorological instruments will for most pupils be of little value in practical life, but an understanding of the meaning of weather signs as illustrated in the phenomena of the air will not be forgotten and will be of perpetual use.

The air, the water, and the earth, and their relation to living things, forms the basis of physical geography. A real knowledge of these things should be developed through a concrete study of them as they are open to observation in the neighborhood. With a fundamental observational and experimental knowledge, pictures and descriptions of other parts of the earth can be brought in to extend this knowledge as much as is thought best.

To be able to make use of the laboratory of nature out of doors is of far more consequence than pouring over maps and reading instruments indoors. If the school is situated in a region covered by a contour map, this should be made a basis of the map study. The geographic features of the neighborhood should be emphasized and made the main basis of the work, but the pupil should not be left wholly uninformed about those not represented in the region open to observation.

Now let us look into some of the reasons why we should use our influence against the introduction of general science into the first high school year. In the first place, the results should be and are as far as the thing has been tried out, far inferior to those which a properly conducted course in physical geography gives. There is no harmony or unity in the array of diverse facts placed before the pupils. The giving in succession lessons and experiments dealing with unrelated facts from every field of knowledge begins nowhere and ends nowhere. When the course is finished the pupils will carry away but a fleeting memory of things seen and done. It is in reality but a course in nature

study, and as I shall try to show later, a nature study of the wrong kind.

It will be interesting to note the topics given in the first laboratory manual which has been published representing the general science idea. Of the 35 exercises, fifteen are problems properly belonging in a course in domestic science; nine are experiments in physics proper; three represent astronomy and geography; one meteorology; four botany; and two mineralogy.

The problems in domestic science form about one half of the list. This may or may not be a fair sample of the proposed work in general science. It at least brings out one fact, and that is the likelihood of conflict between the two. Domestic science is rapidly gaining a foothold in our high schools, at least six in the state giving it in the present year. While its elements are drawn from the different sciences, it is a fairly coherent body of facts given with a definite object in view. While it is possible that domestic science, like agriculture, will not be given as a formal course in the first year, yet it can be readily seen that there is opportunity for much useless duplication.

I will quote the first paragraph of the introduction to the manual mentioned above because it seems extremely pertinent to the matter under discussion. The authors, Messrs. Russell and Kelly, are teachers in the Central High School, Springfield, Mass. The paragraph reads as follows: Physics, botany and biology have each been thoroughly tried as a first year subject in high schools, and each has failed to give the pupils adequate returns for the time and labor expended. Physics has failed because teachers have attempted to teach the subject in its entirety, with an eye solely to college preparation. Botany has failed for lack of teachers trained to present the subject in its living form. Biology has failed because it is a subject too deep for the age of the pupil, requiring as it does skill in dissection, clearness in reasoning, and the ability to differentiate. Moreover, no one science will ever arouse and hold the interest of a whole class, especially first year pupils.

It seems to me that in the above paragraph we have distinctly given several good reasons why general science will meet the same fate that the authors state has overtaken the teaching of individual sciences, and a strong argument in favor of the geographic basis.

While theoretically it is possible to give a course in general science embracing facts from every field, yet in actual experi-

ence such a course will generally be no more than one, or possibly two, sciences. In most cases there is little doubt that it will be physics or chemistry. There is no one man in the University of California capable of giving an all-round science course, as is shown in the course offered the present year. Can we expect to find many all-round men in the high school? As a rule each has his own specialty, his own particular interests, and the course given will be built up largely along the lines of that interest.

There is another line of approach to the question under discussion, and that is from the side of nature study. You may think that I am stretching a point to refer to high school science in connection with nature study, but as a matter of fact the conceptions behind this elementary science notion are practically the same as those underlying nature study, at least that kind of nature study which has found expression in our schools. Both attack natural phenomena from the standpoint of interest, of information, and of furnishing a basis for formal science. Both have no definite order or system.

The university committee as well as others who are proposing to recommend this general science idea have failed to analyze the situation and see its real implication. At this stage in his development the pupil should be prepared to work toward some definite end, but a miscellaneous lot of exercises can furnish no such end. This is the fundamental difficulty with nature study. The nature study idea of the elementary school has been struggling along for some years without gaining any strong foothold, and as a movement is in many parts of the country, particularly in California, a failure at the present time.

There can be no doubt that the ideas which we have attempted to embody in nature study constitute the most vital phases of the newer, concrete practical education, but we must acknowledge that there is something wrong or they would have revolutionized the work of the whole elementary school system. Nature study as it has been given in practice has lacked system and unity, definitely organized plans and ends. An examination of most courses of nature study bears out this criticism. We see grouped together an infinite number of heterogeneous facts without order or definite aim. The standpoint of the general science idea is so nearly that of this wrong nature study that we can predict in advance that it will fail just as surely as nature study has failed.

A light is just dawning in the minds of some of our nature study people which I fully believe is destined to lead us on to a

new and more rational method for acquainting young minds with the meaning of nature about them. This new thought in nature study is based on the notion that all phenomena are primarily geographic. This thought is all-embracing and takes us away from the study of things as things merely, and introduces us to them as integral parts of the all-inclusive world about us. For elementary pupils it forbids our taking the facts of nature out of their proper settings and studying them in the school room as so many isolated facts, but shows on the contrary that the only successful method of acquiring broad conceptions of natural phenomena is to know them as they occur conditioned in the world about us, that is, in their geographic relations.

The phenomena of nature do not occur isolated and independent of each other. They never occur as we are accustomed to present them in the laboratory. While the laboratory method for the advanced student who is making an analytic study is the proper and necessary thing, yet for the beginner who should look at things in their broad relations it is all wrong. The fate of the nature study movement guided by this wrong conception should teach us a lesson. The leaf, the insect, the bird and the mineral specimen have been brought into the school room and made the center of lessons which were interesting for the time being, but the outcome of which was worth little to the pupil. The child must be interested in some definite purpose some outcome which is worth while, in order to have the work result in permanent value. Of what value are a few unconnected lessons in physics, chemistry, zoölogy, botany, mineralogy, astronomy, and geography?

Among the first to give expression to this saner thought in nature study is Mr. Stebbins, recently of the Chico Normal School in an article in the *Nature Study Review*. He groups various studies in soil, climate, and insect life about the growth of trees in a school garden. In such a plan it is worth while for the pupil to study the insects which come to destroy his trees; it is worth while to study the soil and climatic conditions, for these have a direct relation to the growth and product of his trees. This plan gives a natural foundation for nature study and is essentially geographic in its basal conceptions. That is, the various phenomena of nature which are taken up are studied in the light of their actual relations in the world. Geography in its true and broad sense is the study of the earth as an organism,

and of the various facts, biological, chemical and physical, which go to make up its complex existence.

The materials of geography, then, are drawn in large measure from the same substratum of fact as the materials of general science, but while general science takes them up as facts and leaves them as facts, geography weaves them into a unified and connected whole, and that whole is the world in which the pupil lives.

When we examine things as they are exhibited in the world about us we are then studying geography. Isolate these, bring them into the laboratory, and carry on observations and experiments upon them as so many separate and distinct facts, and we are looking at them from the standpoint of formal science. When studying the bird from the geographic standpoint we examine it in the light of its environment, how this environment has affected its habits, character, and distribution. From the standpoint of science we would study the bird merely as a bird, without regard to its surroundings. We would study its structure, life history, and dissect it, perhaps. The geographic viewpoint naturally comes first, for it takes things as we find them in the world, and helps us to understand our surroundings. Each of these two attitudes has its proper sphere, but substitute one for the other and we get confusion and chaos.

Science is cold, abstract, impersonal. Geography is the same thing vitalized. We might say that general science is essentially geographic with the geographic concept left out. It is the skeleton without the flesh and life given it by geography. Why are we trying to delude ourselves by thinking we have discovered something new and better in the general science idea, when in reality it is but the dead skeleton of physical geography? I believe that no possible argument can be advanced to invalidate this statement. In just so far as the exponents of general science attempt to put system, order and unity into their scheme, in order to avoid the criticism that it is a discordant aggregate of facts from every field, they are getting over onto the ground of geography.

I have seen outlines of courses in general science which contain many topics taken over directly from physical geography. It will depend entirely upon the teacher whether such a course is really given from the science side or from that of geography. It would be interesting indeed to find an exponent of general science giving a course in many ways essentially physical geography.

I think we may consider the rise of the general science idea as in a certain sense a protest against the formal and lifeless teaching of physical geography, but have we any assurance that general science will be any better taught? In fact, if our analysis is correct, it will be much more difficult to get any really good results from a course made up of such diverse and disconnected elements. When we have succeeded in thoroughly impressing science teachers with the importance of physical geography as an all-round subject especially adapted to first year pupils, we shall cease to hear about the advantages of general science. I feel convinced that science teachers do not generally understand what geography stands for, and it is the bounden duty of all those interested in physical geography to see that not only the character of the instruction be improved, but that the fundamental ideas back of it be brought clearly to the front.

During the past year there has been much discussion as to the place and scope of physical geography. This is bound to result in better teaching and a truer appreciation of its value to first year high school pupils. We shall have a greater appreciation for the broadly cultural side of the study and less for the mechanical details. As, for example, the study of the land is one of the most important parts of the subject, but when its investigation becomes an end in itself its value is lost for pupils of this stage. They need to see how the situation, character, and slopes of the land are related to living things and to man and his activities in particular.

The question of physical geography versus general science for first year pupils resolves itself into a critical survey of the advantages of each when viewed from the standpoint of general utility and cultural value. We should not accept as true the assertions that are sometimes made that physical geography is a useless, unpractical, theoretic subject not adaptable to first year pupils, but rather attempt to show its direct elucidation of the practical problems of life.

The recently published report of the N. E. A. committee on secondary school geography shows that there is a widespread movement looking toward an uplifting and better appreciation of the subject. While I cannot subscribe to everything in the report, yet there are certain things in it which we can agree on and accept as of great importance. One is that life relations should be made more prominent; another, that the subject be presented from the standpoint of the high school rather than to

attempt to conform its teaching to college requirements; and a third, that the subject be required of every pupil in the first year of the secondary school.

With a fuller realization of the possibilities of physical geography we must accord the subject the place given it in the above report. We must start an active campaign, which shall have for its object the placing of the subject in every secondary school and before every pupil.

With physical geography a required subject and reasonably well taught there is not the shadow of an excuse for the presence of general science in the high school. As a protest against the ideals which have been current in the teaching of physical geography it will have accomplished its purpose.

With biology, chemistry and physics arranged in the order given in the second, third and fourth years, the only place for an all-round earth science course is in the first year. Here it will affect by far the larger number of students, while of necessity, if placed in a later year, it will be more technical and taken by only a fraction of those enrolled.

THE ARRANGEMENT OF THE MATHEMATICAL STUDIES IN THE HIGH SCHOOL COURSES—A COMPARISON WITH THE FRENCH SYSTEM.

By Ernest B. Skinner,

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In this country we have become so accustomed to a course in mathematics beginning with algebra five hours a week throughout the first year of the high school course, followed at intervals by plane geometry, solid geometry, and a second course in algebra, with the order to be determined according to the fancy of the reigning principal, that we scarcely consider the possibility of a better arrangement. It may be indeed that our American way is best, but the conspicuous success of some of the foreign secondary schools, notably those of France and Germany, ought at least to make us willing to consider the subject of arrangement of work.

In reports to teachers' associations and in many public discussions much emphasis has been placed upon the value of preliminary or propædeutic courses in geometry. That the more

elementary parts of geometry are better adapted to the instruction of children than the greater part of the algebra of the first year is not questioned by anyone who has given the subject careful thought, yet most of our pupils are never introduced to geometry in any form until they reach the second year of the high school and in many cases geometry is delayed till the third or fourth year. Then it is presented in the most formidable fashion as a full grown science with very little done to adapt the presentation to the needs of beginners. The worst feature of this arrangement is that for the great majority all the algebra is crowded into the first year of the course and given when the pupils are not able to comprehend it. It is just at this point that the foreign programs differ most widely from our own.

The French and German schools most nearly comparable to our American high schools are the French Lycée and the German Gymnasium and Realschule. Both are under strict governmental supervision and their courses of study are prescribed by central administrative bureaus. For the sake of definiteness comparison is made with the French schools alone. In these schools the secondary instruction covers a period of seven years divided into two cycles of four and three years, respectively, and the pupils begin the work at approximately the age of eleven years. Some of the provisions of the program which will strike the American teacher as differing most from our own practice are the following:

1. Drawing is begun in the first of the three "preparatory" years preceding the secondary instruction and is carried on continuously to the end of the second cycle. Consequently, French boys receive no less than two years' instruction in this subject and a considerable part of this instruction is made subsidiary to the work in geometry.

2. For the first four years the work in mathematics is given two or three hours a week; except that for a single year, the "fourth class in B," takes four hours. The total number of hours carried ranges from 22 to 24 per week, so that mathematics constitutes only one eighth to one seventh of the work instead of one fifth as in the case of American schools.

3. The various mathematical subjects are begun in the most elementary way possible and they are taken *simultaneously*.

4. Algebra, geometry, and science are all carried on side by side from the time they are begun to the end of the course.

5. Arithmetic is studied as a science rather than as an art.

Some idea of the arrangement of the work may be gained from an enumeration of the subjects in "class four B" at which period the boy would be thirteen or fourteen years of age. Four hours a week are given to the work. The following is abbreviated from the "Plan d'Etudes et Program d' Enseignement."

ARITHMETIC.

Decimal numeration, addition and subtraction, multiplication and division of entire numbers. Divisibility by 2, 5, 9, 3. Greatest common divisor and least common multiple, the rule and not the demonstration given for the latter. Definition of prime numbers and decomposition into prime factors. Necessary and sufficient condition that of two numbers decomposed into prime factors one should be divisible by the other. Ordinary fractions. Decimal fractions, square root given by practical rule *without* the theory.

ALGEBRA.

The use of letters and algebraic formulas. Positive and negative numbers to represent magnitudes having two senses. Lengths measured from a point, time, force and degrees on a thermometer. Addition, subtraction, multiplication and division of positive and negative numbers. Change of the origin of abscissas or of the origin of time. Equation of uniform motion. Determination of the position of a point by means of the ratio of its distances from two fixed points in the line.

GEOMETRY.

I. Proportional lines. Relative positions of the two points which divide a right line in a given ratio. Properties of the bisectors of a triangle. Similar triangles and similar polygons. Power of a point with respect to a circle. Metric relations in a right triangle, and in any triangle whatever, construction of a fourth proportional and a mean proportional.

II. Regular polygons: Square, hexagon and equilateral triangle.

III. Measure of the circumference, *simply announcing the value of* π.

IV. Measure of the area of the rectangle, the parallelogram, the triangle, the trapezoid and polygons. Ratio of the area of two similar polygons. Area of the circle.

V. Surveying.

The radical difference between the above program, which is given to "Division A" a year later than to "Division B," and our own arrangement becomes apparent when one notes that operations with polynomials and the solution of equations come at a *later period*. Quadratic equations and solid geometry are taken up in the same year.

One would be rash to assert that the French program would be the best for American schools for it has been constructed almost wholly for those boys who expect to go to the university. In it the great majority of French citizens have little interest. Nevertheless, this French program has many excellent features that are well worth our serious consideration and possibly cautious imitation.

The strongest feature, it seems to me, is the postponement of the formal algebra to the later years of the course, when the pupils are better prepared for it. It is noteworthy that this is done without losing connection with the arithmetic of the earlier part of the course. This has the further advantage that it makes room for the more elementary parts of geometry. There can be no question that the elementary parts of geometry are more interesting to pupils and in every way better adapted to the needs of children of twelve to fourteen than formal algebra.

Scarcely less important is the close relation that exists between drawing and geometry. Each is made to supplement the other with the result that a most effective training in form and in space relations is made possible. It would require but a very slight rearrangement in our school curriculum to make possible the coördination of drawing and the early part of geometry. The drawing is given in most of our grade schools and it would be an easy matter to replace some of the less useful parts of the arithmetic by the elements of geometry.

These two reforms, namely, the earlier introduction of the simpler parts of geometry in connection with drawing and the postponement of the formal algebra are certainly worthy of serious consideration by American teachers.

A most admirable account of the German program and its workings is given in Young's *The Teaching of Mathematics in the Higher Schools of Prussia,* published by Longmans, Green, and Company. For an account of the French program one must go to the "Plan d' Études et Programmes d' Enseignement dans les Lycées et Colleges de Garcons," Delalain Fréres, Paris. This little book is an official publication of the French department of public instruction and gives the course of study for boys in great detail. A similar publication entitled, "Plan d' Études et Programmes de l'Enseignement des jeunes Filles," and published by the same firm, gives the course of study for the schools for girls. Fortunately a full account of the French secondary schools has been made accessible to English readers through Professor F. E. Farrington's recent book, *French Secondary Schools,* published early this year by Longmans, Green, and Company.

A SLIDE RULE FOR CLASS ROOM USE.

By Ernest W. Ponzer,

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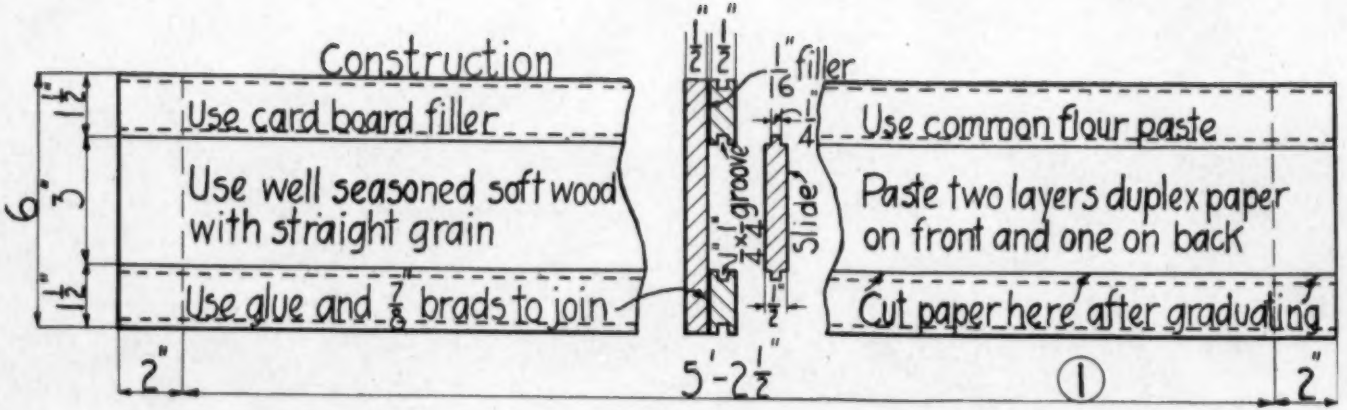
That a world-wide movement in mathematical circles aiming at a greater efficiency in the teaching of mathematics has been gradually gaining momentum during the last ten years can hardly be denied. It may further be stated that many teachers of mathematics in secondary schools have caught this spirit of reform—and lived up to it—some time in advance of their colleagues in the colleges and universities. At present we have the spectacle of an international committee of university professors of mathematics at work on the problem in response to the demand for this greater efficiency. Undoubtedly, one of the causes of this demand for efficiency is found in the recent remarkable development of all branches of applied science, especially those of technology. The spirit of efficiency is prevalent there to a marked degree; in fact, of primary importance. Especially is this true in engineering practice in the United States. The teacher of mathematics, either in the secondary school or university, must get this spirit in order that he may use the short time a student is with him to the best advantage.

We have heard much of the Perry movement, laboratory methods, correlation, humanizing of mathematics, and other movements, all trying to solve the same problem and all helping to secure a greater efficiency. In this day we do not hesitate to use, in fact it is our duty to use, all those aids which will help round out any course in mathematics from arithmetic up. Teachers no longer hesitate to use graphical methods to illustrate many principles in algebra, nor refuse to employ analytical methods when these help fix the principles of geometry.

In this connection we wish to make the suggestion that there is no valid reason why the study, and especially the use of mathematical instruments, should be deferred to the latter years of a student's college course. The writer has used for several years in his work with freshman and sophomore students in the university several such home-made instruments, one of which, a slide rule of liberal size, has been fastened to the wall of the class room; and he has further insisted that every student be prepared, after a reasonable time, to check up his numerical work on the same.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Use well seasoned soft wood with straight grain
Use glue and 7/8 brads to join
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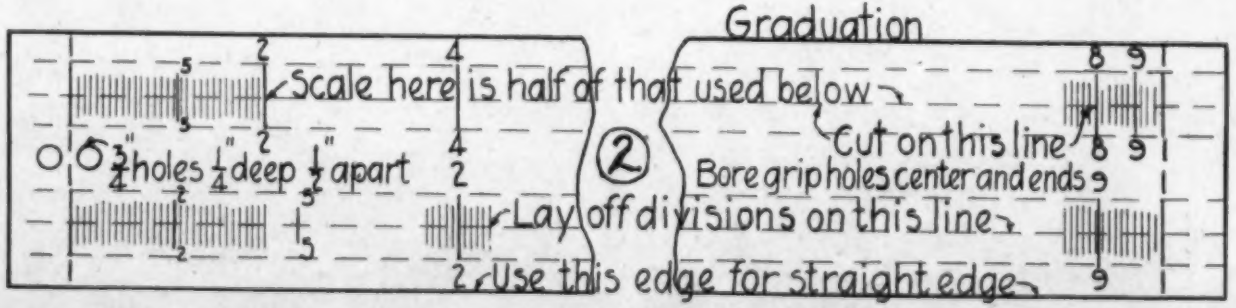
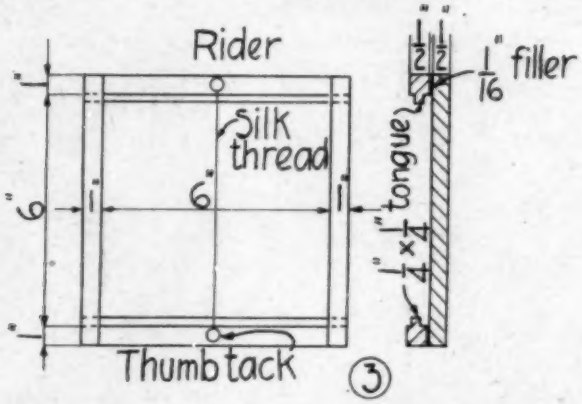
2"
①


Graduation
Scale here is half of that used below
3/4" holes 1/4" deep 1/2" apart
②
Cut on this line
Bore grip holes center and ends
Lay off divisions on this line
Use this edge for straight edge

The theory of the slide rule is simple and well known; its application soon becomes more so, yet the knowledge of the principle and ability to use the same may be regarded as a secondary object, the main or fundamental idea in view being to check up results. Here is where we should learn our lesson from everyday life. To check up results implies that there should be a result to a problem, and further that the student's mathematical conscience should tell him when the result is correct. Any independent method which helps him develop this self-reliance is worth while, and the slide rule is preëminently such an aid.



③

However, we wish to go a step further at this point and venture the suggestion that every teacher of secondary mathematics would find in it an inspiration for better work and suitable for use as soon as the student has studied the subject of exponents. We are not advising that every high school student should carry his slide rule, bought ready made, with him; rather should he be able to construct one, and that of any size which may appeal to him. Sufficient explanation is given in connection with the accompanying working drawings which will enable any student having done the rudiments of manual training to construct such a rule for class room use, or one on a smaller scale for desk use.

It will be noted that no provision is made for the direct reading of trigonometric functions, the idea being to stick to fundamentals and to obtain ease of operation, the rule being fastened to the wall with screws. It will be necessary to supplement its use with tables; but perhaps, from a pedagogical standpoint, this may be regarded as an advantage.

It may hardly be necessary to state here that the numbers on the rule are laid off according to their logarithms—exponents—

and yet it may be in order to mention that 1,000 divisions each 1/16 inch in length were laid off on the face of the rule, as shown by the light lines in Fig. (2). Evidently, by referring to a table of logarithms, the figure 2 is placed opposite the 301'st of these divisions from the left and similarly the figure 3 opposite the 477.1 division. Various devices for estimating the tenths will suggest themselves, among others a piece of paper on which are measured ten equal divisions laid at an angle between two consecutive lines. The number of subdivisions between two numbers will depend on the numbers, and perhaps it would be best to have, say a 10 inch rule for a pattern. On the upper scale 2 would be laid off opposite the 150.5 division and 3 opposite the division corresponding to the logarithm of 1.732. If a rule is desired giving also cubes and cube roots directly it will be seen that the extra scale to be laid off should be simply ⅓ that of the lower scale. Holes ¾ inch in diameter bored in pairs, with centers 1½ inches apart, at either end and in the middle, will serve as grips for moving the slide. Figure (3) gives a working drawing of the rider, the cross hair of which can readily be adjusted by means of the thumb-tacks.

The rule, once installed, will be used frequently and be found eminently practical; yet should it serve no other purpose than just to stimulate the student's interest and help develop his mathematical sense it would be found well worth while.

OFFICIAL DEMONSTRATIONS CONVINCING.

Most of the leading mining men of this country have long believed that coal dust is in itself an agent of disastrous explosion, but until public demonstrations had been made at the government testing station at Pittsburg, many doubted that it possessed explosive power without the aid of fire damp. Its explosibility is now unquestioned and it is generally admitted that many so-called "windy shots" and "powder explosions" have been really dust explosions.

IMITATION GEMS.

The one quality of most of gems that cannot be duplicated successfully in their imitation is their hardness. Glass will yield to a file, while gems will not. The glass used in making imitation gems usually has a high percentage of lead in its composition. The lead makes it soft, but gives it a great brilliancy. The glass is commonly known as paste or strass. Uncolored, it affords a good imitation of the diamond, and it can be colored with metallic oxides to produce remarkably good imitations of other gems.

NEW SOLUTION OF HIGHER EQUATIONS.

By H. A. Foering,
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The following method will solve an algebraic equation of any degree, giving all the roots, real and imaginary, expressed in infinite series. The method is simple, complete, and unfailing. It can be applied by the secondary school teacher far more readily than the methods in ordinary use. Besides, no method adapted to secondary school work has heretofore been known that would give the imaginary roots of higher equations. A peculiarity of the method is that the amount of labor depends, not on the degree of the equation, but on the number of terms in the equation.

In the proceedings of the American Philosophical Society, Volume XLVII, 1908, will be found a rigorous demonstration of the method by the discoverer, Professor P. A. Lambert, of Lehigh University, from which the author quotes directly in several instances. The reader is also referred to the Bulletin of the American Mathematical Society, 2nd Series, Vol. XIV, No. 10, pp. 467-477, July, 1908. This article will merely illustrate the method by concrete examples.

Given an equation such as $y^5-4y^4+7y^3-863=0$. The method consists in:

First, introducing a factor x into all the terms but two of the given equation.

Second, in expanding y, which is now an implicit algebraic function of x, into a power series in x.

Third, placing x equal to unity in this power series. The resulting value of y, if convergent, is a root of the given equation expressed in terms of the coefficients and exponents of the equation.

Let us illustrate these three operations, and after that solve a few equations.

First, introducing a factor x in every term but two.

A three term equation such as $y^3-15y-126=0$ gives rise to a set of three auxiliary equations when x is thus introduced, namely:

$$\text{Set M} \begin{cases} xy^3-15y-126=0 \\ y^3-15y-126x=0 \\ y^3-15xy-126=0 \end{cases}$$

A four term equation such as $y^5-4y^4-7y^3-863=0$ gives rise to a set of six auxiliary equations, namely:

$$\text{Set N} \begin{cases} y^5-4y^4-7xy^3-863x=0 \\ y^5-4xy^4-7y^3-863x=0 \\ xy^5-4y^4-7xy^2-863=0 \\ xy^5-4xy^4-7y^3-863=0 \\ xy^5-4y^4-7y^3-863x=0 \\ y^5-4xy^4-7xy^2-863=0 \end{cases}$$

A five term equation gives rise to ten equations, and in general an equation of n terms gives rise to $\frac{n(n-1)}{2}$ equations.

Second, each equation in set M, set N..... defines y as an algebraic function of x, which may be expanded into a power series in x by assuming

(a) $y=A+Bx+Cx^2+Dx^3+\ldots$

We shall need y^2, y^3, y^4 and y^5 in the several problems to follow, and though these values are readily obtained, for convenience we shall give the result of these operations and refer to them.

(b) $y^2=A^2+2ABx+(2AC+B^2)x^2+(2AD+2BC)x^3+(2AE+2BD+C^2)x^4+\cdots$

(c) $y^3=A^3+3A^2Bx+(3A^2C+3AB^2)x^2+(3A^2D+6ABC+B^3)x^3+(3A^2E+6ABD+3Ac^2+3B^2C)x^4+\cdots$

(d) $y^4=A^4+4A^3Bx+(4A^3C+6A^2B^2)x^2+(4A^3D+12A^2BC+4AB^3)x^3+\ldots$

(e) $y^5=A^5+5A^4Bx+(5A^4C+10A^3B^23x^2+(5A^4D+20A^3BC+10A^2B^3)x^3+\ldots$

Third, the substitution of these values of y, y^2, y^3, y^4, y^5..... in the equations of Set M, Set N..... gives us identities. Placing the coefficients of the various powers of x in these identities equal to zero, by the method of undetermined coefficients, we may then find the values of A, B, C, D..... Consequently, if the power series $y=A+Bx+Cx^2+Dx^3+\ldots$ is convergent, A, B, C, D.....being known, and x being equal to unity, the value of y, a root of the equation, becomes known.

Let us take a few concrete examples. With a little patient practice secondary school pupils may solve difficult examples with facility. The only knowledge of advanced algebra required in this solution is that of the subject of undetermined coefficients and the ability to solve the two term equation of some such form as $5y^3-7=0$. We shall in this paper determine the question of convergency by trial. The application of the rules for con-

vergency is rather too complicated for secondary school pupils, though these rules, when applied, determine without exception which of the auxiliary equations contain the roots sought.

It will soon be apparent to those solving a few examples that this method is far less laborious than may appear at first sight, far less so indeed than the application of Sturm's Theorem and Horner's Method.

EXAMPLE A.

Let us take the equation $z^3-3z^2-2z+5=0$. As the solution is simplified by diminishing the number of terms, though this is not essential to the solution, we shall remove a term, the second, whence we obtain

$$y^3-5y+1=0$$

Introducing x, we get the following auxiliary equations

(a) $y^3-5xy+1=0$

(b) $xy^3-5y+1=0$

(c) $y^3-5y+x=0$

Substituting in (a) the values of y and y^3 obtained on a previous page, we obtain the following identity

$$0\equiv\begin{vmatrix}A^3\\+1\end{vmatrix}+\begin{vmatrix}3A^2B\\-5A\end{vmatrix}x+\begin{vmatrix}(3AB^2+3AC^2)\\-5B\end{vmatrix}x^2+\begin{vmatrix}(3A^2D+B^3+6ABC)\\-5C\end{vmatrix}x^3+\begin{vmatrix}(3A^2E+6ABD+3AC^2+3B^2C)\\-5D\end{vmatrix}x^4$$

Whence $A^3+1=0$ $\quad\therefore A=-1,\ \dfrac{1\pm\sqrt{-3}}{2}$

$3A^2B-5A=0$ $\quad\therefore B=\dfrac{5}{3A}=-\dfrac{5}{3},$

and $\dfrac{10(1\pm\sqrt{-3})}{12}$

$3AB^2+3A^2C-5B=0$ $\quad\therefore C=0$

$3A^2D+B^3+6ABC-5C=0$ $\quad\therefore D=-\dfrac{125}{81A^5}=1.543..$

and $\dfrac{125(1\pm\sqrt{-3})}{162}$

$3A^2E+6ABD+3AC^2+3B^2C=0$ $\therefore E=\dfrac{625}{243A^7}=-2.57..$

and $\dfrac{625(1\mp\sqrt{-3})}{486}$

Inserting these numerical values, $y=A+B+C+D+E$ is probably a diverging series, but in any event it is better for the secondary student to pass on to a consideration of the other auxiliary equations. Let us therefore try

(b) $xy^3-5y+1=0$

$$0\equiv\begin{vmatrix}-5A & +A^3 & x+3A^2B & x^2+(3AB^2+3A^2C) & x^3\\ +1 & -5B & -5C & -5D & \end{vmatrix}$$

$-5A+1=0 \qquad \therefore A=.2$

$A^3-5B=0 \qquad \therefore B=\dfrac{A^3}{5}=0.0016$

$3A^2B-5C=0 \qquad \therefore C=\dfrac{3A^5}{25}=0.0000384$

$\therefore y=A+B+C \qquad =0.2016384$

Taking (c)

$y^3-5y+x=0$

$$0\equiv\begin{vmatrix}A^3 & +3A^2B & x+(3AB^2+3A^2C) & x^2+(3A^2D+B^3+6ABC) & \\ -5A & -5B & -5C & -5D & \\ & +1 & & & \end{vmatrix}$$

$$x^3+(3A^2E+6ABD+3AC^2+3B^2C)\,|\,x^4\ldots.$$
$$-5E$$

Whence $A^3-5A=0 \qquad \therefore A=\pm\sqrt{5}= \pm 2.236075\ldots.$

$3A^2B-5B+=0 \qquad \therefore B=\dfrac{1}{5-3A^2}=-0.1$

$3AB^2+3A^2C-5C=0 \qquad \therefore C=\dfrac{3A}{(5-3A^2)^3}=\mp 0.006708\ldots.$

$3A^2D+B^3+6ABC-5D=0. \therefore D=\dfrac{5+15A^2}{(5-3A^2)}=-0.0008$

$y=A+B+C+D=2.128467\ldots\ldots$ and $-2.330447\ldots\ldots$

The three values of z in the equation $z^3-3z^2-2z+5=0$ are therefore $1.2016384\ldots\ldots$, $3.128467\ldots\ldots$ and $-1.330447\ldots\ldots$ All of which results are correct to three or more decimal places.

Example B.

We shall next consider the three term equation

$y^3-15y-126=0$

a cubic, the roots of which by Cardan's method are found to be 6 and $-3\pm 2\sqrt{-3}$. Though the method illustrated in this article determines the roots expressed in infinite series, yet the summation of a few terms, unless converging very slowly, will indicate the ultimate summation to result in commensurable quantities. Having solved the first example at great length, to save space we shall hereafter condense the solutions.

The auxiliary equations are

(a) $xy^3-15y-126=0$

(b) $y^3-15y-126x=0$

(c) $y^3-15xy-126=0$

(a) A=8.4.., B=39.5, a diverging series.

(b) A=$\pm\sqrt{15}$, B=−4.2, C=±7.05, D=26.1 and −21.4, a diverging series.

(c) $O \equiv \begin{vmatrix} A^3 & +3A^2B \\ 126 & -15A \end{vmatrix} x + \begin{vmatrix} (3A^2C+3AB^2) \\ -15B \end{vmatrix} x^2 + \begin{vmatrix} (3A^2D+6ABC+B^3) \\ -15C \end{vmatrix} x^3 ..$

Whence $A^3-126=0$ $\therefore A=5.0133..\ -2.5065..\pm 2.5065..\sqrt{-3}$

$B=\frac{5}{A}$ $\therefore B=0.9973..\ -0.4987..\mp 0.4987..\sqrt{-3}$

$C=0$

$D=-\frac{125}{378A^2}$ $\therefore D=-0.01316..\ 0.00657..\mp 0.00657..\sqrt{-3}$

$E=\frac{625}{47628A}$ $\therefore E=+0.00261..-0.00131..\mp 0.00131..\sqrt{-3}$

$y=A+B+C+D+E+\text{etc.}=6.0000..\ -3.0000..\pm 2.0000..\sqrt{-3}$

Example C.

We shall conclude this article by giving briefly a summary of the solution of the following four term equation of the fourth degree.

$$y^4-3y^2+75y-10{,}000=0$$

The auxiliary equation $y^4-3xy^2+75y-10{,}000=0$ contains all the roots. Upon substituting for y, y^2, and y^4 as before shown, we obtain

A=	10.0000,	−10.0000,
	$10.00\sqrt{-1}$,	$-10.00\sqrt{-1}$.
B=	−0.1125,	−0.2625,
	$0.1875-0.075\sqrt{-1}$,	$0.1875+0.075\sqrt{-1}$.
C=	−0.0029,	−0.0029,
	$-0.0000015+0.0039\sqrt{-1}$,	$0.0000015-0.0039\sqrt{-1}$.
$\therefore y$=	9.876,	−10.261,
	$0.1875+9.927\sqrt{-1}$,	$0.1875-9.927\sqrt{-1}$.

It may also be added in conclusion that the solution of any equation may be expressed in a formula involving the coefficients and exponents of the given equation, and A, so that if the user is able to apply the convergency rules and select the correct auxiliary equations, the labor involved in solving may be still further lessened.

EXAMPLES OF CLASSIFICATION IN SCHOOL WORK.

By C. Elliott,
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Probably the word classification is seldom used in schools except in connection with natural history, and the title of this article may perhaps suggest that it deals with the nature-study department of the school, and that the classifications considered are those of minerals, or of butterflies, or other insects.

A comparison of such classifications with those considered below will show, however, that the two kinds could not profitably be taken together, the classifications of natural history differing in two important ways as a rule from those which will be discussed here.

Two kinds of classification of things which differ from each other in one respect are recognized in schools, namely, scalar and non-scalar classifications. If the respect in which the things differ is one which admits of the classes being arranged in a definite order, the difference is scalar. For example, differences of temperature, or density, or hardness are scalar differences, but differences of shape, or color, or taste are non-scalar.

It will perhaps be said that, even if the difference is non-scalar, yet, if the classes have been given a purely arbitrary order, the classification should be called a scalar one. This is doubtless correct, but, for the sake of clearness, and because the distinction of scalar and non-scalar is, as regards differences, well-known, it will be assumed that to a scalar difference corresponds a scalar classification, and to a non-scalar difference a non-scalar classification.

If the objects classified differ in two respects, a similar distinction applies, for neither, or one, or both respects, may be scalar. Thus for example the two respects might be color and shape, or color and hardness, or hardness and density.

But such classifications may be distinguished from one another in a different way, and one to which less attention is apt to be paid, for we may ask whether the two respects do or do not form a classification and cross-classification. The usual name for a classification and cross-classification is duplex, but, though examples of duplexes are common, the name has not yet gained a footing in school books. The case where the objects differing in two respects do form a Duplex will be considered here, the contrary case being what one would expect to find in a natural history classification.

As examples of a Duplex may be given:

(1) The classification of noun-forms by declension and case in a Latin Grammar.
(2) The classification of simple salts by metal and acid radical.
(3) The classification of the cards of a pack by suit and value.
(4) The classification of days of a year by day of month and number of month.
(5) Finally, a model of a Duplex, for example, of a color-shape Duplex, can be made by coloring and shaping pieces of cardboard.

In examples (1) and (2) above neither respect is scalar, and this is also what would generally be the case in a natural history classification.

In example (3) one respect only (in many card games) is scalar, namely, the value of the cards of a suit.

In example (4) both respects are scalar, for the days of a month have a definite order, and so have the months of a year, so that the Duplex might be called a scalar duplex. In making a model to represent a Scalar Duplex, it would be natural to arrange the classes of one respect so as to form columns, those of the other respects forming rows.

Similar remarks hold true of the classifications of things differing from each other in three respects. If a classification by any two of the three respects gives a duplex, then the entire classification is called a Triplex. A model of a Triplex can be made from pieces of cardboard differing from each other in three respects, such as color, shape, and size. Similarly a model of a quadruplex can be made from pieces differing in four respects, such as color, shape, size, and markings. In short, one may say that a model can be made of any multiplex though it becomes a rather laborious task if the number of respects is greater than three, and it is of course impossible to arrange a Scalar model of a Scalar multiplex if the number of respects is greater than three.

For a Scalar multiplex it is usual to employ the terms "space," or "manifold," and the classified things are called "points." Different names are also given to the spaces according to the number of respects, or, as they say are termed, "dimensions," in which the points differ from each other; for example, a space of one dimension is called a "line," a space of two dimensions a "surface."

In schools it is usual to begin the study of multiplexes, under the title of "Geometry," with the scalar triplex constructed, or assumed to have been constructed, by aid of the meter rule and set square, the use of which may be compared with the use of paint and scissors in constructing a color-shape duplex. Words like "point," "line," "straight line," "plane" are introduced as if they had no meaning except in regard to that particular triplex. Whether the subject can really be best approached through this one triplex is a question the discussion of which can hardly be said to have begun, and it may be that future opinion will regard discontinuous spaces as more suitable for beginners than continuous ones.

Exception may be taken to the Euclidean triplex for beginners on the ground, amongst others, that ideas like point, line, surface, cannot be realized in practice so far as that particular triplex is concerned, the finest dot made by a pen having a definite area, the finest streak a definite breadth. If, however, we consider say a color-shape duplex, arranged in some arbitrary order so as to form a space, then there is no difficulty in realizing a point, for a point is then merely one of the classified things. A further possible objection to the present use in schools of the Euclidean triplex is that it makes the passage to the study of spaces of more dimensions than three needlessly difficult. For with purely geometrical ideas and reasoning become interwoven unconsciously ideas of work, or fatigue, or human capabilities, which, if they truly belonged there, would make the idea of four-dimensional spaces absurd. The history of the subject shows that it was only when attention was paid to other manifolds that spaces of more dimensions than three were studied.

To sum up, the classifications considered here are multiplexes, and not those which, in opposition, might be called natural history classifications.

Multiplexes may conveniently be divided into scalar multiplexes and non-scalar ones, other names for the former being spaces or manifolds. Natural history classifications besides being not multiplexes are generally non-scalar.

Finally, spaces may be divided into continuous and discontinuous spaces, both sorts admitting of classification by the number of their dimensions.

THE VALUE OF CHEMISTRY AS A HIGH SCHOOL SUBJECT.

By J. H. Allen,

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(*Continued from the November issue.*)

Table 1.

Showing values of manufactured products by groups as taken from the Twelfth United States Census Report for 1900:

Reference	Group	Value
Vol. VII, p. CXLV	1. Foods and kindred products	$2,277,702,010
"	2. Textiles	1,637,489,484
"	3. Iron and Steel	1,793,490,908
"	4. Lumber and its mfgrs.	1,030,906,579
"	5. Leather and its finished prods.	583,731,046
"	6. Paper and Printing	606,317,768
"	7. Liquors and Beverages	495,504,167
"	8. Chemicals and Allied products	552,891,877
"	9. Clay, Glass and Stone products	293,564,235
"	10. Metals and metallic products other than Iron and Steel	748,795,464
"	11. Tobacco	283,076,546
"	12. Vehicles for transportation	508,649,129
"	13. Shipbuilding	74,578,158
"	14. Miscellaneous	1,004,092,294
"	15. Hand Tools	1,183,615,478
		$13,004,400,143

Table 2.

Showing values of some purely chemical products for year 1900 as shown by the Twelfth United States Census Report.

Reference	Products	Value
Vol. X, p. 526	Chemicals (acids, bases, and salts)	$78,414,840
	Dyestuffs (including tanning materials)	7,767,226
	Essential Oils	854,401
	Explosives (including miscellaneous)	16,950,976
	Fertilizers	45,911,382
	Paints and Varnishes	71,313,392
		$221,217,217

Table 3.

Showing values of some products of metallic industries and for mines and quarries as shown by the Twelfth United States Census Report.

Reference	Industry	Year	Value
Vol. X p. 4	Iron	1900	$804,034,918
" " " 100	Tin	"	61,912,619
" " " 128	Lead, Copper, and Zinc	"	358,786,472
Special Report 1902 on Mines and Quarries	Value of all products of Mines and Quarries	1902	$892,506,519

A study of these tables will give the thoughtful person some idea of what chemistry is to progress when out of all the groups of industries shown in Table 2 it is shown that there are perhaps only groups 4, 11, 12, 13, 14, and 15 that do not employ direct chemical processes, and that all the others do. Still even these enumerated must make use of chemical processes to some extent and use chemical products as raw material. When on the other hand we look at the immense use made of chemical processes in all the other groups, and in the mining industry we must, it seems, form a high estimate of the role that chemistry has played and will continue more and more to play in the development of our industries, and the progress of civilization.

To Commerce and Nation.

We have already shown the value of chemistry to the agricultural and manufacturing interests of this country and given the estimate of these industries in money values as shown by government statistics for 1900. We have pointed out that these interests are constantly being served by chemistry; and that chemistry and chemical processes are responsible to an enormous degree—in many cases wholly so for the success of these enterprises. Thus as these two interests constitute a very large part of commerce we have seen some ways wherein chemistry serves commerce. But commerce does not consist of production alone as represented by agriculture, manufacturing, mining, etc., all of which depend to a greater or less degree upon chemistry, there still remains another very important factor not yet considered, viz., distribution, in which transportation plays perhaps the most important part. When we recall the service chemistry has rendered transportation facilities as already mentioned in connection with the discovery of oxygen and its later bearing on metallurgical processes of iron and steel we are compelled to admit that the interests of commerce have been greatly advanced through chemistry. Where indeed would be our com-

merce to-day without our railroads and ironclad ocean liners? We often hear complaints of high rates of transportation, but what would it be if it still cost nearly $200 to make a ton of steel rails? How much commerce would we have under such conditions? We forget, I think, what all this cheapness of manufacture means in this age. We even forget to what it is due, and think of these improvements just as though they had always been or had happened as a matter of course, if indeed we ever stop to think of them at all.

But this is not the only way in which chemistry has served commercial distribution. Chemistry is daily putting new articles on the market, thus stimulating trade. Still on the other hand chemistry does some things not to be approved of, or rather unscrupulous manufacturers and dealers make use of chemistry to adulterate almost everything we use, but on the other hand we see another valuable service that chemistry renders us in that we are compelled to employ it to detect these frauds. Concerning the value of chemical analysis to commerce Professor Austin says:[4] "What is the effect of the increasing accuracy in chemical analysis upon our civilization? It places every article on its true basis of intrinsic worth. Metals, ores, and articles of commerce have a certain value depending on the nature and amount of their valuable constituents. This is determined by analysis. And business is at once placed upon a solid foundation and insecurity in value ceases. Chemical analysis is the balance wheel of trade. It establishes responsibility. It says to the cheat, honored and respected though he may be—and there are thousands of them in the community, 'Thou art the man.' It compels accuracy of statement, rigid truth. * * *" "It makes honesty compulsory. Articles of food and drink must be what they claim to be, no more, no less. A man who adulterates is a liar and a thief, if not also a coward. He may cause ruin, disaster, and death. A man who buys adulterated articles (knowingly) is a fool. Chemical analysis is one of the greatest agents for the protection of a community that there is, and its power is increasing every day. * * *" "And so chemical analysis disclosing to the world where true worth is to be found develops countries and gives them resources which may enable them to compete with great nations." Therefore we see that chemistry protects the honest merchant and manufacturer as well as the community. This fact many merchants

[4]The Chemical Factor in Human Progress. Sci. Am. s vol. 54: 22404.

make use of to protect themselves and their customers. The government employs experts in all its departments, as for instance at every navy yard will be found a corps of chemists testing every article purchased by the government. Every bit of steel is tested not only as to strength but also chemically; all rations, paints, varnishes, oils, ammunition, etc., must pass the chemists' tests. Even the coal used must be chemically tested as to its efficiency. Thus this brings us to the interest of the nation in chemistry. As has been previously stated, England and Germany as governments have manifested their appreciation of the value of science teaching and especially that of chemistry and physics by aiding and establishing various scientific schools, and our own country to some extent through the Morril and other educational bills. Certainly a science which is so intimately connected with such great interests as the agricultural, manufacturing, and commercial interests of a country is worthy the best thought and most hearty support of the national government in providing that it shall be taught in the schools.

Thus again another very important requisite for a government's welfare, in fact its very existence, depends upon its means of defense. Gunpowder is mentioned among other things as being one of the most powerful factors toward bringing about the renaissance. In connection with this fact it is also true that when it was invented those nations most advanced in science have made the most rapid progress in civilization and national greatness. This invention, although no one knows as to the when or the how of its origin, was very likely brought about by accident in some chemist's dingy laboratory, a place despised and avoided by some of our friends of the culture studies who forgot that the classics in art and literature owe much of their own development and growth, glorious and far-reaching in their beneficial effects as they may be, to this same little chemist's laboratory in the dim past and to its successor even to the present day. For to this one product of the chemist's shop has it been possible for civilized nations to wage successful wars, and to ensure the possibility for cultivating the arts of peace. On its account has it been possible for nations to advance in social and moral status; to extend commerce; enlarge industries and build great cities; to perfect governments; undertake great engineering feats which, by the way, would be impossible without dynamite. Through this preparation for more effective warfare has come peace to the world; churches and schools have been

built and general education extended to the masses of mankind bringing within the reach of all the elevating influence of the arts of letters, the fine arts, and music.

Sociological.

Herbert Spencer says regarding sociology:[5] "The only history that is of practical value is what may be called Descriptive Sociology. And the highest office which the historian can discharge is that of so narrating the lives of nations as to furnish materials for Comparative Sociology, and for the subsequent determination of the ultimate laws to which social phenomena conform.

"But now mark, that even supposing an adequate stock of this truly valuable historical knowledge has been acquired it is of comparatively little use without the key. And this key is to be found only in science. Without an acquaintance with the general truths of biology and psychology rational interpretation of social phenomena is impossible."

That these statements are true in the main will be pretty generally admitted, especially the claims of science in interpreting social phenomena. So for mere interpretation of these social movements we do not make any very urgent claims for chemistry. It is true it may to some extent do so indirectly through biology, and it is more to the direct relation of chemistry to biology, if I may so put it, as a factor in helping to solve some of the problems confronting the sociologist to which I wish to call especial attention.

Since industrial movements and conditions affect the welfare of society, and these movements are traceable often to improvements in chemical processes, the sociologist will admit that he must recognize in chemistry a factor to be reckoned with.

Some of the problems confronting the sociologist of the day are those of the congested conditions of the city with its slums; the exodus from country to city; the questions arising how to prevent the continuation of these things; how to improve the social conditions of the people of the country as well as of those of the cities.

What a boon it would be to the lives of the farming classes did they but understand more of agricultural chemistry and of agriculture in general! It would revolutionize the social con-

[5] Education. Herbert Spencer. pp. 69-70.

ditions of the country. It would reduce the size of our farms, bring the people from the crowded cities to the country to fresh air and sunshine and away from vice. If chemistry, domestic and agricultural, were understood by the farmers and their families their homes would be made more comfortable, sanitary, and attractive. There would be a large income and such conservation of resources and products that they would not only be elevated in their aspirations and tastes but also be more likely to have the means for the gratification of them, and there would be less desire to leave the home or the farm because the city offered better attractions, especially when the opportunities for a large social intercourse are brought about through reducing the size of the farms and enlargement of the country towns.

Of course chemistry and science cannot solve this whole problem. There are other things to take into account, largely political in nature, but with an educated farming community reforms in this line would also follow. Then if improved agriculture would tend to raise the conditions of the farming population, place the farmers and their families in a condition for their moral and social betterment, and thus tend to stem the tide pouring from the country into the city if not indeed to turn it the other way—and there is little doubt that this would be the logical result—then chemistry is an important factor in the advancement of social conditions, since we have seen how vitally it affects these interests.

Speaking of science in general, from some quarters comes the objection that science often works great injuries to large bodies of society, since through scientific inventions large numbers of people are frequently being thrown out of employment. To this we say: "Very true, we do see less of chair porters, night men, and sawyers our forefathers required."[6] But what has become of these men since new processes have rendered them no longer needed in their old capacities? They have been compelled to prepare for and fill higher positions. Thus they have generally gone into places usually of greater responsibility and remuneration. Thus for example, the large fields upon which the madder plant was grown was converted into fields for other products, and many of the laborers compelled to seek other employments when the artificial methods for making Alizarin were discovered. In this way science and

[6] What Science is Doing for the World. Exchange from the Nineteenth Century. Sci. Am., v. 49: 20094.

chemistry as much as any other is all along cutting off the simpler callings of life by new inventions and discoveries, and is forcing the human family up the social scale by compelling them to use their higher powers for the maintenance of life. Quoting reference No. 6 again, "Thus while science takes away with one hand it bestows with the other: but what it takes away are the low class occupations, and what it gives are the high class ones, demanding intelligence and cultivating it. The general tendency is therefore humanizing. * * *" Thus the general drift of the whole social scale is steadily upward in proportion as science provides intelligent occupations at the upper end and abolishes those that are more or less brute like at the lower end, and so humanity as a whole is the gainer. There is therefore no reason to feel uneasy at a prospect of overeducation." And I may add to feel that science works an injury by indirectly throwing men out of employment. But again someone may object that these inventions, discoveries, and processes which minister to the social advancement and comforts of man are benefiting meanwhile to an immense degree a certain small number who by reason of circumstances or industrial conditions control them rather than of being of the benefit that they should be in general. To this we say that it is no fault of science if this is true. This is a problem for society itself to solve.

The service has been of untold value that chemistry has rendered society in the analysis of foods; public sanitation, such as the analysis of sewage and public drinking water; in ventilation and a multitude of other ways in which the public health is protected. Then, too, chemistry serves to protect the public by helping detect crime; so that our police and criminal courts, our coroners as well as our boards of health, are all under obligations to chemistry. Thus under this head William Harmon Norton says:[7] "Civilization is safeguarded by science" (and in this case by chemical science) "not only from the irruption of savage hordes" (i. e. through the more effective defense obtained through the use of gunpowder) "but also from the invasion of disease, from such epidemics as that which in the middle of the fourteenth century swept away more than half of the population of England, and twenty-five millions of people in Europe. To-day when the plague appears in San Francisco or London, it excites little more alarm than Gibraltar would feel at the assault of the Moor."

[7] The Social Service of Chemistry. Sci. Am. s vol. 51: 21239. William Harmon Norton, late Pres. Iowa Academy of Sciences.

Another service that chemistry has performed is the influence it has had in developing our methods of reasoning and arriving at truth through experimental evidence. Sir William Crookes, the great English physicist, has pointed this out very clearly as follows:[8] "We may point out that chemistry more than any other science has taught us the art of experimental inquiry, or, as it might be otherwise called, the systematic interrogation of nature. The English language makes a clear distinction between experience and experiment, though the distinction is often overlooked. If we only experienced or observed some result our knowledge of it may be very vague. But if we know it experimentally the word implies that we have produced the phenomena under known conditions. Now in chemistry we can reproduce any particular phenomenon we are studying as often as we please. We can note and we can vary any and every condition which may affect or modify the result. If such result is novel or unexpected the investigation will be repeated by others, so that any error committed whether of fact or of interpretation is sure to be eliminated. In other sciences, e. g. biological, experimentation is far more difficult. We cannot always obtain the materials we need, nor can we reproduce at will the phenomena under investigation. Hence, then, chemistry is a study indispensable to civilization, since experimental inquiry whenever practicable is the type and model of the method of arriving at truth."

Thus we see that almost at whatever angle we view it chemistry has its sociological significance as well as a service industrial and commercial. In fact it is a commonplace saying that the civilization of a country is measured by the quantity of sulphuric acid it consumes.

To Medicine and Biology.

Again quoting Professor Norton (Ref. 8): "Among civilized nations within the last five centuries the death rate has been so lowered that the average duration of human life has nearly doubled. Medicine no longer attacks disease with charm and nostrum or exorcism; she obtains her weapons from the armory of science. From chemistry she brings a pure materia medica, new compounds, new processes, new methods of diagnosis, and anæsthetics which have made surgery painless." He further comments upon the work of Pasteur in bacteriology. Although

[8] The Role of Chemistry in Civilization. Forum, vol. 6, p. 448-449. Sir William Crookes.

Pasteur was a great bacteriologist, yet his work and its bearing on organic chemistry has been truly marvelous. His results have been studied and extended until to-day the pathologist can by chemical means recognize and distinguish the various bacteria and further through Lister's researches in antiseptics the surgeon nowadays performs operations with entire confidence of success that not long ago would never have been attempted.

Not only in surgery, medicine, and bacteriology has chemistry rendered great service, but also to physiology. Chemistry explains the digestion and the composition of various tissues of the body. Chemistry also aids hygiene by pointing out food values; value of various substances to the system as oxygen in respiration and the injurious effects of other substances as carbonic acid gas.

Thus chemistry has always been the support of medicine and more and more as the chemical processes going on within the human system are understood where conditions are normal as well as abnormal, so much the more will the physician use chemistry for the counteraction of those abnormal processes called disease and thereby check them.

To Daily Life.

Not only in the ways mentioned in showing the importance of chemistry to agriculture and manufacturing does chemistry remind us how it ministers to our daily life, whether in sickness or in health, but to the thoughtful and those acquainted with the facts a multitude of objects remind us daily of the obligations our necessities and luxuries owe in some way or other to chemistry. Thus in our homes we have in the domestic department articles for bleaching, scrubbing, renovating, disinfecting, laundry use, and such like; in the kitchen the gas range and lights burning gas with its devices for economizing fuel by means of the burning of oxygen, the cooking and baking involving more or less chemistry; in our dining-rooms the table set with porcelain ware depending for its strength and beauty of finish upon chemical processes, the cutlery which reminds us of metallurgical and chemical processes, the morning paper and the morning letters; in our bedrooms the articles of the toilet, perfumes, soap, dentifrices, shoe polish, etc.; in the parlor the paintings, the beautiful tapestries, rugs, and carpets depending for their beautiful coloring upon technical chemical knowledge and skill, the photographs, and even the piano's beautiful coat of varnish—all

these remind us in some measure of what chemistry has done for our daily comfort. These instances might be multiplied in great number, but we will leave the subject here by saying that there is hardly an article of daily use that does not depend at some point of its completion upon some process of chemistry.

As an Educational Factor.

To get at the value of chemistry as a study in our educational systems there are several questions to first be considered and determined, chief of which are, "What IS educational?" or "What is or should be the true object of education?" Then having settled this point determine if possible the relative value of those studies by means of which we accomplish the real objects of education. A great deal has been said and written on these points since before the days of Plato to the present time. We do not propose to settle these questions here, but merely to point out from what has already been said that which appears to us to be a reasonable answer to the problems involved.

In considering the aims of education McMurry[9] quotes the opinions of some of the great writers of education as follows:

John Stuart Mill: "Education includes whatever we do for ourselves and whatever is done for us by others for the express purpose of bringing us nearer to the perfection of our nature."

Plato: "The purpose of education is to give to the body and to the soul all the beauty and all the perfection of which they are capable."

Herbert Spencer: "Education is the preparation for complete living."

Stein: "Education is the harmonious and equable evolution of human faculties by a method based upon the nature of the mind for developing all the faculties of the soul for stirring up and nourishing all the principles of life, while shunning all one-sided culture, and taking account of the sentiments upon which the strength and worth of men depend."

Compayre: "Education is the sum of the reflective efforts by which we aid nature in the development of the physical, intellectual, and moral faculties of man in view of his perfection, his happiness, and his social destination."

McMurry discusses this subject and arrives at the conclusion that the highest and central aim of education should be moral character building.

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[9]General Method. McMurry. pp. 10, 11.

Professor James describes education by calling it, "The organization of acquired habits of conduct and tendencies to behavior."[10]

While all these definitions are good, and at first sight seem to be somewhat at variance, it seems that that given by Spencer includes what is said in all, or at least the essence of each either by the word "preparation" or by "complete living," for if we consider Plato's definition, does not preparation for complete living contemplate the giving to the body and the soul all the beauty and all the perfection of which they are capable?

That of Professor James relates more to the manner of "preparation" and so we might go over all the definitions and find that "complete living" or "preparation" comprehends the thought expressed in all, especially when we consider what activities that Spencer included as those composing complete human life. He classifies them as follows in order of importance (see Ref. 12):

"1. Those activities which directly minister to self-preservation.

"2. Those activities which by securing the necessities of life indirectly minister to self-preservation.

"3. Those activities which have for their end the rearing and discipline of offspring.

"4. Those activities which are involved in the maintenance of proper and social relations.

"5. Those miscellaneous activities which make up the leisure part of life, devoted to the tastes and feelings."

Thus it will be seen in the above that moral, æsthetic, and intellectual culture is provided for in the above plan as well as that of the material, for activities relating to citizenship must be prepared for by moral training. The same may be said for training for parenthood, and the miscellaneous refinements of life which also includes the æsthetic and intellectual training.

The question of relative value of studies is an interesting one generally answered in favor of those studies of which the writer's specialty forms a part. Spencer, though noted less as a naturalist than as a philosopher, although he is criticised as such, gave the sciences as the most important study, as he believed that they did more than any other studies to serve the activities mentioned. This view is contradicted by many, especially by those who hold to the theory that moral training is the primary object of educa-

[10] Talks on Psychology and Life's Ideals. James. p. 29.

tion, such as the followers of Herbart, who think historical material furnishes the best factors for moral training or organizing of acquired habits of conduct and tendencies to behavior, and would place history as the most important subject. Now the question arises as to whether the preservation of life or moral training is or should be the first concern of education. If the former, then all must admit science, and especially chemistry, has the right to precedence; however, if the latter, then there may be room for debate. While we are willing to admit that history furnishes a rich fund of material that may be used toward moral training, we are inclined to believe that when we know science as well as we do history that we will see in it just as many opportunities for teaching morals and training in moral habits of thought and action; and I would regret very much to have any history teacher think that he had the monopoly on moral training or for the teachers of science to think that that important function of education had only a small place, if any at all, in his work. The fact is that whether we know it or not science does furnish means for the highest forms of moral, æsthetic, intellectual and spiritual culture, and therefore we are opposed to giving it second place in the curriculum. We do not say it should have first place as Spencer claims for it, for we are not so far advanced from the old idea of the value of the languages and literature, although he wrote almost a half century ago. So we claim for science an equal position with any study in the curriculum, and that chemistry as a branch of science which has served and is still serving man as few if any other sciences do, is entitled to rank along with any study we have. By considering Spencer's classification of human activities we are able thereby, it seems, to get on a good way toward the solution of the question as to whether education should be merely for the inculcation of knowledge or simply for power, or whether it should include both. There have been those camped on each side of this question, but the tendency has been, it seems, to be the minimizing of knowledge and a worship of power to an unwarranted extent. Power to react properly under all the ordinary circumstances of life, and power to apply the facts of knowledge, while very important and perhaps the most important of the two, still is worthless, or I may say powerless, without a fund of knowledge for its basis. Thus in nearly every activity mentioned, *e. g.*, that of self-preservation, a knowledge of scientific or economic facts is important, or otherwise how could we

apply them had we as much power as we please? Therefore, I do not sympathize with those who conceive the only end or chief end of education should be the cultivation of power alone, be that mental, physical or otherwise; hence, while it has been the chief argument that sciences, and chemistry as such, develops power to think, to observe, and to apply, all of which may be true to a large extent, yet it seems that it must not omit the furnishing of information or of giving of chemical or scientific knowledge as well, or it has failed, for if power to think, observe and apply is the only excuse offered for chemistry in our schools, then we might as well omit it entirely, for if history or any other subject is properly taught it will do the same, for psychologists tell us that faculties to observe, and to reason in general, are not developed by particular studies, but that power to observe and reason along the lines of these studies alone are developed, and we have the fall of the doctrine of formal discipline.

Therefore it occurs to me that the educational value of chemistry consists in both preparation for a technical education or the imparting of valuable practical knowledge as well as the power to apply it, and in furnishing in its methods of instruction through experiment a valuable training in morals by teaching a regard for truth and honesty, as well as developing an analytical turn of mind and ability in experimental methods of inquiry.

When I say that education should give knowledge as well as power, I do not mean that teaching of chemistry in secondary schools should give such knowledge or training as that required of a practical chemist, but that it should give so much knowledge as will be of practical use to the average person in daily life, and such as will give him an intelligent appreciation of so great and important a science. This should be broad enough and thorough enough to furnish a basis for further study in a technical school or entrance to a university.

As we have seen that chemistry so vitally affects our interests in so many ways, its importance demands at least as much as outlined for the average man, and for those preparing for a technical vocation, no other study is of greater importance.

IMMENSE QUANTITIES OF PHOSPHATE.

The areas examined contain more than 267 million tons of high-grade phosphate rock, very little of which has yet been mined, and it is probable that the deposits extend far beyond the areas examined, forming, perhaps, the largest phosphate field in the world.

REPORT OF THE COMMITTEE ON FUNDAMENTALS OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.*

I. Introduction.

After a preliminary view of the field, and in the absence of explicit instructions, your committee soon reached the conclusion that its function is not primarily to bring together and tabulate the actual formal utterances of the various sections; but is rather to digest these various reports and the discussions that have clustered about them, and to reformulate, so far as time and the ability of the committee will allow, a new synthesis of those appreciations and tendencies that have marked the recent utterances of the sections of this association. In other words we have assumed that you, through your committee, are making a conscious effort to take stock of our philosophy of using the sciences and mathematics as a means of education.

II. Historical; and Sources of Materials.

Of the five sections of this association, three—Biology, Chemistry, and Physics—have had reports in which the question of fundamentals has been more or less formally handled. The section of Mathematics has had formal reports on the essentials of Algebra, on the essentials of Geometry, and on the Unification of Secondary Mathematics. These utterances we have considered as paralleling the reports in the three sections mentioned. The Earth Science Section alone has given no formal report to which the committee can appeal.

In addition to these reports there have been symposia in *School Science and Mathematics* upon secondary biology, physics, and chemistry. Numerous special articles have also appeared in the same journal voicing the views of members on matter respecting which we are to report. It has appeared wise to the committee to digest all these expressions of opinion in our report. This report then may be looked upon as an abbreviated survey of the formal expression of opinion, in part collective and in part individual, that has been maturing through our society during the last few years.

III. Propositions of Primary Rank, Pertinent to all Sections.

1. The general purposes of education and of life must be kept in view, in any sound delimitation of the essential matter or

*To be presented before the meeting of the Central Association of Science and Mathematics Teachers at Cleveland, Ohio, Nov. 25, 1910.

method of any science. This *general* meaning of education must always be allowed to condition the *special* purposes of the sciences in our scheme of education.

In the language of the biologist the purpose of education is best expressed as "Adaptation—with the retaining of adaptability." This means that an individual shall be so developed that he shall be able, and disposed, to make sound reactions to the combinations of external and internal stimuli that come to him; that this shall be done with the least outlay of time and trial—even though the stimuli themselves are subject to fluctuation. It means forming habits of responding, without losing the power to change the method of response whenever changing conditions warrant.

2. In nature the power of adaptation which an individual secures comes by a natural hereditary recapitulation of the acquirements of the race. In human education there is an effort to secure an *artificial hastening* of the essentials of this recapitulation, in order that proper reactions to our highly complex stimuli may be able to take place in the individual more promptly and more surely. The *artificial* nature of this *hastening* introduces two most important corollaries which present the chief difficulties in practice:—

(a) Because the process is artificial, we are in danger of failing to respect the fundamental facts of ontogeny, and thus lose some part of the *natural inherited motives* to wholesome activity, and individual development. Here arises the problem of sound *motivation* in respect to the pupil.

(b) Because the process must be *accelerated,* wise *selection* must be made of the small amount of essential materials that have been accumulated by the activity of the race—out of the relatively large amount of rubbish, or at least less essential matter. Here arises the problem of *selection of educational materials.*

3. In respect then to all sciences that are to be used in education, we may say that the fundamental problems that need solution are:—

(a) The proper motivation of the pupil for fullest activity.

(b) The wiser selection of the materials that will bring the pupil most quickly and surely to the point where he will respond soundly to really significant stimuli.

(c) The getting on the part of the student of what we call the "Scientific" spirit and method—as opposed to arbitrary or artificial attitudes.

4. Most fundamental to the securing of these results in any study is the full, sound, normal, mental reaction of the pupil. Every exercise by which we educate should allow and produce a complete mental reaction. It is not enough merely to secure the pupil's assent to a fact, or to get an observation properly made and recorded, or to memorize a set of words or relations. The pupil's mind should always be encouraged to "follow through" to whatever response, in the way of final conclusion or explanation seems sound in the light of his then knowledge and capabilities. This is quite independent of the final *correctness* of that conclusion. It is more important that the reactions be allowed, be complete, and be the student's own, than that they be rigorously right. It is a very easy thing to add new elements to the stimuli in order both to teach the pupil that conclusions are liable to be wrong, and to force his conclusion closer to that moving equilibrium which we call truth. Indeed this process is easier than to re-galvanize the soul whose interest and ability to reach conclusions have been aborted by a continual denial of the right.

Much of the breaking down on the part of our educational processes to-day is probably due to this mode of "taxation without representation," in respect to personality.

5. The sciences and mathematics are especially valuable in this educational program, in that they give training in the ability to eliminate the *personal equation*. The humanistic studies—illustrated by the literatures, music, and fine arts—on the other hand, exalt the personal point of view. They demand that the individual shall, as much as possible, read himself into the situation. In these studies he gets out of the work very much what he is able to read into it. His result is more of a measure of himself. This has its value in culture; but it needs exactly the check which the scientific studies can contribute: for scientific conclusions are liable to be valuable in exact proportion as they are freed from the personal bias and viewpoint. They may, therefore, be fairly regarded as essential to every scheme of sound balanced education, and complementary to the humanistic studies.

6. This very source of their strength—the elimination of the personal element in method—is a reason for one of the chief weaknesses that have thus far developed in scientific studies. We have come to deal with the sciences in education too much in an abstract or merely logical way, and as unrelated to life. We have falsely imagined that the impersonality of the scientific

method must be carried over into the *matter* and the *purpose* of the courses.

All human culture must finally begin and end in human life and experience, no matter what the impersonality of the method. The problems, particularly in secondary education, must begin in the experience of the pupil, and find their terminal application in the broad life-necessities of mankind; and not in mere science as such.

The systematic or logical motive in respect to matter and purpose must give place to the personal or ontogenetic motive. The student—his nature, his order of development, and his needs—must take precedence, whenever necessary, over either the logic of the subject or the historical order of its development. We have been prone to assume, without scientific foundation, that the logical order of the subject *must be* the ontogenetic one.

7. It follows from these facts that in working out the pedagogy of *every* subject in the curriculum, the psychologists and students of the child are of an order of importance quite on a par with the expert in the particular subject. It means that the teacher of science must either become, himself, a psychologist of the immature mind, or must work hand in hand with the psychologist who can appreciate properly the values of the special science. It is vital that this synthesis be effected.

8. Therefore it is that every class room and laboratory of whatever sort, must come to be considered as a laboratory of experimental psychology. We must, as scientists, bring the same acumen and methods of experimentation, which have resulted in such marvelous discoveries in respect to material things, into the very study of the educational necessities of the subject itself. This means that every teacher who is fitted should be a research student in the psychology of his subject. It means experimentation in definite and controlled ways, by people both capable and disposed to devise experiments, to measure results, to deduce conclusions, and to hold their conclusions subject to revision when proper. But to have *any value* these experiments must be scientifically conducted by competent people.

Our present pedagogical selections and procedures in science are apparently as tentative, and probably as inaccurate and unsound, as were the processes of medicine five hundred years ago. Indeed the parallel is not a forced one. We have been as prone as the earlier physicians to believe in educational *specifics;* to think that we could produce this or that definite development

of faculties with this or that special exercise. We are coming now, just as the physicians did before us, to realize that if there be specifics for the development of certain particular results, they are much more complex than we have dreamed. We are beginning to understand that the chief thing is to assist nature; in other words to respect the natural individual processes in all our efforts to guide the mind's development.

9. While educational "specifics" are to be looked upon with suspicion, it is necessary on the other hand that the teachers shall have in mind not merely this general physiological task of assisting nature. He should have definite ideals of purpose and method for the course as a whole; ideals of interest and appreciation; of habits of diligence and accuracy and complete reaction; of disposition to criticise and retest results; of feeling of responsibility; of determination for social service, etc. The teacher should be diagnostician enough to sense the particular need, and practitioner enough to know the natural conditions demanded and to mold the materials to meet the needs. Every exercise in every subject should be chosen and conducted for some definite part of this purpose of assisting nature; chosen not dogmatically, but flexibly and with openness of mind.

This is *motivation of the teacher,* and is as important as that of the pupil.

10. Thus it comes about that the success in discovering and applying sound principles in these and other subjects depends on the teacher and his insight. He is the most significant "fundamental" which needs consideration. The greatest handicap to-day in the work of this association is poor teachers: not poor scientists nor mathematicians; but poor teachers.

11. The present period is one of protest against methods and matter; a period of dissatisfaction and retesting the curriculum; a period of study of the grounds and history of teaching—more general and more promising than has ever been experienced in the history of the subjects of these five sections since they really had a part in the curriculum. Hitherto we have been so interested in the absolutely revolutionary and wholesome contributions we have made to the pedagogy of other subjects that we have neglected to keep our own house in order.

12. For various reasons the need of this pedagogical dissatisfaction and readjustment is more quickly and acutely felt by the *secondary* teachers of science and mathematics than among those of the colleges and universities. The latter have been much

more concerned with the training that fits *to go on* with the science, as science. The former confront the life-phases more directly, and serve a much larger body of people.

It follows therefore that in all these subjects, vitally related to experience, the solutions must finally be worked out without special reference to college entrance requirements. The secondary schools are closer to life. And just as soon as their pedagogical necessities are reasonably demonstrated—or even as soon as the direction which the experiments must take is determined—the college and university people must adjust themselves to the conditions.

13. The changes that shall be made as the way becomes clear should be evolutionary rather than revolutionary.

14. There is coming to be a general recognition that there are no "water-tight compartments" either in personality or in, or among, the sciences. This fact is leading to a general openness to synthetic courses. We hear much of nature study; of biology instead of zoölogy, botany, and physiology; of elementary science courses instead of separate beginning courses in physics, chemistry, earth science, etc.; of synthesized "spiral" courses in mathematics, unifying arithmetic, algebra, and geometry. Whether this is pedagogically the final word or not, it is a very manifest present tendency in this association. It represents at least another approximation to truth. Here is another point at which competent experimentation is called for.

IV. Some Propositions of Secondary Rank, Pertinent to All Sections.

1. In all our secondary science we are after the *relations* between things, and between causes and effects. Too much of the current science teaching asks pupils to get an excessive accumulation of facts without getting a true understanding of their relations. Efforts at excessive accumulation of facts are usually made at the expense of the development of the logical processes and deeper mental activity.

2. Since we must omit in our teaching of youth so much of what the race has accomplished it is poor pedagogy to use—and to drill in—artificial, abstract, unattractive, or relatively useless matter, whenever the desired results in personality can be gained equally well by the use of real, concrete, interesting, or intrinsically worth while matter. The appreciation that discipline for future efficiency is not in antithesis to the things needed for pres-

ent growth and development—as expressed by present interests, powers, and activities—is increasing. Biologically this involves a confidence in the naturalness and truthfulness of ontogeny to the significant realities to which human life must react.

If on the other hand there are phases of personality, either in respect to knowledge or effectiveness in our complex relations, that are not reached by the utilitarian material, it is equally poor pedagogy to deny the use of the less useful and more abstract. The *child's nature* should not be sacrificed to the fetish—either of *utilitarianism* or of *logic*.

3. Roughly speaking we should look toward the following results, to the good average student, in the teaching of science and mathematics—by which we may test any course:

a. *Information.*

There should be a good knowledge of certain fundamental facts, principles, and theories, and of the appropriate vocabulary; a reasonable understanding of certain related matter—and of the history of the subject as related to human development. Just what these various knowledges should be in each subject must be determined by adequate experimentation within the departments.

b. *Skill.*

There should be skill and accuracy in observation; ability to appreciate exact meanings of necessary terms and to use terms with precision; ability to reason correctly; power to appreciate, to attack, and to solve problems in accordance with scientific principles.

c. *Habits.*

There should be habits of interest, of diligence, of exactness, of openness of mind, of seeking and weighing evidence, of discrimination between essential and incidental elements, of "following through"—as an intellectual process—to the sane conclusion; of satisfaction in proper mental functioning: in a word, there should be the *scientific habit.*

d. *Ideals.*

There should be—as a by-product of such studies—ideals of efficiency, of mental integrity and honesty, and of social service.

It is well to remember that *skill* is retained longer than *information;* and *habits* than either.

4. The pupil should not be encouraged to look at these secondary courses as comprising certain sciences to be mastered,

nor as subjects in which to fit for college; but as a means of introducing to new fields of human interest and appreciation; as furnishing tools for solving new problems; as creating general intelligence for life activities; and as giving a valuable method of thinking and of getting truthful conclusions.

5. In all this work the student's own experiences should bulk large. The (to him) more obvious phenomena in any of these departments should be largely the basis and starting point of courses. At this age the more concrete the beginning phenomena can be made the more real will be the later appreciation.

6. It is criminal on the part of a teacher to require, or even allow, memorization of matter that *may be* reasoned out; or the presentation by students of material that is not understood.

7. In the light of what we do *not* know in these fields, it is folly to insist upon too great an appearance of *rigor* in the processes, in any of these courses. Accuracy in method should be insisted upon; but a pretense of rigor in results which in the nature of the case cannot be fully demonstrated begets a species of dogmatism—of spurious foundation—which should be far from our scientific results.

8. Uniform courses are out of the question. They are unattainable in practice, and undesirable in theory—except from the point of view of college entrance requirements. This search for uniformity in the various schools has done much to secure indifferent teaching, by discouraging the individuality and initiative of the teacher and of the pupils.

The most essential things in any course are variable; e. g., the teacher, the mental qualities of the pupils, and their interests and needs. If, with these variables, we insist on uniform courses we do it at the possible expense of natural factors which it is vital that we should not only respect but cultivate.

9. In all the work of our sections, while the laboratory is vitally important, there is increasing demand that we recognize the limitations of the laboratory, the outline, and the syllabus. We have been somewhat disposed to make a kind of fetish of these. In reality they are only aids to the main thing.

It is out of the question to make the elementary student depend on the laboratory for any large proportion of what he should get. Life is too short for this. The work in the laboratory is the solvent for the larger mass of materials, relations, principles, which he cannot stop to verify.

The set outline or syllabus should deal only with the barest

outlines; the specific problems and procedures should be developed by the teacher and class under the impulse of interest—guided by the well-matured purpose of the teacher for the particular exercise.

The attempt to follow detailed manuals is responsible for some of the mediocrity and lack of inspiration and initiative complained of in secondary education.

10. Student interest and initiative are essential factors in all successful teaching. To admit this is no denial of the necessity of vigor and soundness in all the processes. In arousing and maintaining interest and responsiveness two fundamental facts are to be kept in mind:

a. The *"problem-solving attitude"* on the part of the pupil is a thing to be striven for. Nothing less will satisfy the necessities of the case. But this is not enough.

b. The pupil must be stimulated into the *"problem-raising attitude."* The young child has this. The average high school pupil has been educated out of it. It is a part of the function of secondary science courses to renew it. The problems set for secondary pupils should not merely be related to the student's experience and life; they should as often as possible be the *student's own problems.* These two attitudes are complementary—and together constitute the scientific spirit.

11. As specific devices to give stimulus to the points of view just emphasized, applicable alike in all our sections, the following have value:

a. Numerous applications of the subject to the present life and interests of the pupil and community should be made. This does not mean a commercialization or industrialization of science and mathematics, although these are partial phases of this life-value.

b. Abundant attention should be given to the natural questions of the pupils, as expressing this interest. It is much more important to appreciate, recognize, and guide such interest than to "finish" a subject.

c. Suitable glimpses of the history of the subject may always be made the means of increasing the interest and appreciation.

d. Suggestions of the present incompleteness of the subject, and slight glimpses into the great questions yet to be solved by the investigators, appeal wholesomely to the youthful

sense of wonder, and enlarge the interest.

e. The attempt to cover too much territory should be shunned. All sections seem to be tempted at this point.

f. Give the pupils time. Do not take them along faster than they can go with understanding. The sense of being hurried is not conducive to the scientific spirit nor to sound conclusions.

V. Some Items of Contrast in the Pedagogy of these Subjects.

1. The following grouping of the five subjects will suggest certain vital contrasts:

a. Mathematics.

b. The non-evolutionary sciences—Physics, Chemistry.

c. The evolutionary sciences—Earth Science, Biology.

The developmental idea runs through earth science and biology in such a way as to be a unifying principle—and is not beyond the comprehension and appreciation of the secondary pupil. This is not true of mathematics or of physics or chemistry. Whatever of unifying principle is discoverable in these subjects is of too abstract and recondite a nature to be greatly valuable in the pedagogy of youth.

2. The mathematics of the secondary schools (i. e. higher arithmetic, algebra, geometry) involves much use of the abstract, the symbolic, and subjective. In its organization it has not been emphatic of the concrete and the observational. It is least easy of all the five subjects to motivate with practical, experimental applications, in this intermediate stage of education. In consequence of this fact, and of the facility with which it lends itself to definite and accurate statement and drill, there is a special temptation to an impossible and fictitious *rigor*. Its pedagogic strength lies in the readiness with which the pupil's mental processes and attitudes may be followed and checked; and in the practice it furnishes in analysis and synthesis, and in discriminating the essential and significant elements in a situation.

3. On the other hand, physics, chemistry, earth science, and biology are, or ought to be, primarily observational studies—dealing largely with concrete objects and their relations. Their great strength is that they so naturally allow a good adjustment to the life-needs of the pupil. Physics and chemistry are particularly strong at this point. Physics and chemistry being organized as sciences on the mathematical, rather than the pro-

gressive or evolutional basis, have much of the exactitude of mathematical processes;—and likewise tempt teachers into some of the unpedagogic striving after rigor and quantitative exactness found in mathematics. They combine some of the advantages of mathematics and of the evolutional sciences.

4. Biology, being most complex and variable of all, is not so open to mathematical statement and exactness. It encourages the attitude of *approximation* to truth through the elimination of negligible factors. Its best contribution is in its appeal to the habit of discriminating among the numerous factors that enter into results; in its emphasis on the great unifying and progressive phenomena of all life; in its encouragement to openness of mind—its shibboleth being *"evidence"* rather than "proof"; and in its parallelism with human interests. Its weakness is in a temptation to mere observation and to an appeal to bizarre and unrepresentative phenomena, and a consequent discursiveness and sloppiness in the total result.

5. Considering and reconciling the claims of the various subjects as well as possible, and taking into account conditions as they actually exist in the secondary schools, we make the following suggestions as to time apportionments:

SUBJECT	1st YEAR	2nd YEAR	3rd YEAR	4th YEAR	REMARKS
Mathematics	Required	Required	*Req. †Elect.	Elect.	A "spiral" presentation of Arith., Algebra and Geometry
Introductory Science (Tentative)	Required				Introductory to Earth Science, Physics, Chemistry and Biology
Physics			Required		
Chemistry				Elect.	
Earth Science	*Req. if †El. Sci. not given		Elect., or	Elect.	Earth Science may properly be postponed as a *general synthesis*, if El. Sci. is required
Biology	†Req.	Required	Elect., or	Elect.	Required work should include Biology and Human Physiology

*First half-year.
†Second half-year.

VI. Added Points Respecting the Special Sections.

A. *Mathematics.*

1. The earlier aspects of algebra and geometry should be

presented in the concrete. Later the symbols of abstraction are appropriate.

2. It is illogical to try to conclude the most abstruse and unfamiliar and difficult aspects of one subject before presenting the more concrete and elementary phases of the others. Elementary work should therefore be provided in which computations and the simple processes of algebra and of geometry are combined; and pupils should be encouraged to invent and construct some problems of their own in the interest both of spontaneity and of real contact with life.

3. Following this there should be a systematic treatment of the leading truths of elementary algebra and geometry, care being taken to use each subject in connection with the others.

B. *Chemistry.* (See also Physics.)

1. "The internal organization of chemistry and physics, from the scientific point of view, is largely abstruse and mathematical." The strictly scientific approach to them is neither demanded nor allowed by the nature or needs of the high school student.

2. There is enough of chemistry in practical life to furnish the necessary concrete entrance to the essentials of the subject.

3. The display notebook, as a means of testing the qualification of the pupil, is futile and misleading.

C. *Physics.* (See also Chemistry.)

1. Physics is peculiarly rich in opportunities to bring in concrete, familiar, and useful materials as the foundation of the course. "The first purpose of a beginning course in physics should be to make nature and her ways seem natural."

2. The secondary physics should emphasize the *qualitative* rather than the *quantitative.* There is usually too much of measurement and mathematics. In so much as these enter, they should be incidental.

3. In one year of physics, only principles of the first order of importance should be emphasized.

D. *The Life-Sciences.*

1. Botany and zoölogy should be so handled that human physiology and hygiene, and the elements of anthropology will naturally become the culmination of the course. A recognition of man's place in respect to the lower forms of life should be one of the results of the secondary course in biology.

2. While the human-interest of plants and animals should fill a large place in this course, human interest means much more than commercial or economic interest.

3. There should be a progressive and spiral intermingling of the ecological, physiological, systematic, and economic phases of the subject.

4. Well-selected calendar studies of plants and animals, running through the entire school year, should be a considerable part of this course. This helps secure to the student's interest an extension *in time.*

5. Among the great principles to which the student should be led are: growth and progressive development, both individual and racial; division of labor and differentiation for efficiency; sexual differentiation and its meaning; the economic dependence of man on other organisms; the value of social combination and service; and the natural processes of the human mind itself in passing from observations to conclusions.

E. *Earth Science.*

1. Earth science is, in a sense, the fusion of all the material sciences, and serves both as a good introduction and foundation for the concrete course in elementary or introductory science, and as a concluding synthesis and application of some aspects of the constitutent sciences in the last years of the high school.

2. The earth science subjects, especially geography and physical geography, are rich in possibilities for developing causal relationships from the human interest standpoint. No opportunity should be lost for making such applications as are found in economic and industrial conditions. This phase should be developed especially in the first and second years.

3. Earth science, as developed in our high schools at present, does not really rank as a laboratory or observational science.

4. In the effort to make it more really such a science, there is just at present an undue development of certain means of representation—as topographic maps, charts, and graphs of various kinds—a development out of all proportion either to utility or to educational value.

5. The greatest present need is reasonable delimitation of territory and a development of this to the point where it can really become an observational and experimental subject adapted to school conditions.

6. Nothing in practice is to be gained by the mere device of bringing together the subject matter of the recognized sciences and calling it, synthetically, earth science.

T. W. GALLOWAY, Chairman
D. A. LEHMAN.
MARION WELLER.
WILLIS E. TOWER.

THE FOREST SERVICE OF THE UNITED STATES AND ITS WORK.

By Lois Whitney,
University of Chicago.

The Forest Service is organized as a division of the Department of Agriculture, for the purpose, as the name implies, of managing the United States forests. As early as 1891 the President was authorized to establish forest reserves, which he did immediately. But because there was no provision to use the wood in the reserves, or even to care for it properly, about all that was accomplished was the withdrawal of the forests from public use, only to burn and decay. The reserves made at this time were worth about $2,000,000,000. Soon after this a division of Forestry of the Department of Agriculture was established and in 1897 a law was passed authorizing the use and protection of the national forests. Later the Division of Forestry was changed to the Bureau of Forestry, which in turn became the Forest Service in 1905. The national forests now amount to 195,000,000 acres.

When the reserves were first established they met with great opposition, and perhaps rightly, for it certainly could not benefit the nation much to cut off an available source of revenue with practically no compensation. But since the forests have been systematically cared for, and since the agricultural land that is unavoidably included within the boundaries has been thrown open to settlement and the states containing forests receive ten per cent of all receipts, practically all dissatisfaction from people who really understand the situation has been removed.

The present forest area of the United States is about 550,000,000 acres, or about one fourth of the total area. It has been reduced by fires and destructive lumbering about 300,000,000 acres in the last two centuries. The forests are divided into about five natural divisions, northern, southern, central, Rocky Mountain, and Pacific Coast. The northern forest covers 90,000,000 acres and consists chiefly of white pine, red pine, spruce, hemlock, cedar, fir, and some hard woods. The southern forest comprises 150,000,000 acres and contains yellow pine, hardwoods and cypress. The central forest is about the same size and contains oak, poplar, elm, hickory, chestnut, red gum, ash, and walnut. The Rocky Mountain forest consists of lodge pole pine, larch, spruce, western red cedar, white pine, and firs. The Pa-

cific Coast forest formerly contained the largest trees and the heaviest stand recorded by history or geology. The trees are principally Douglas fir and pine.

About twenty-two per cent of all these forests belong to the United States, the area of the national forests in 1908 being 194,505,325 acres, with a stand of 390,000,000 board feet. They are divided into one hundred and fifty forests grouped in six divisions.

The aim of the Forest Service is to supervise and manage the national forests so as to derive the greatest benefit from them without exhausting them; a wise use and protection of the forests instead of neglect and waste. Some of the particular objects in view in the administration are—the prevention of forest fires, the elimination of waste of wood and damage to young growth by careless logging; the prolonging of the life of wood by scientific preservative treatment; the planting of treeless lands; the settlement of the national forest land and the cooperation with states, individuals, and companies in outlining forest policies and aiding in their development.

The Forest Service of the Department of Agriculture is organized in ten offices with a Forester as the head who is responsible for all the offices. The Associate Forester is his assistant who acts as Forester in his absence. The Special Fiscal Agent receives all the funds from the business and disburses them.

The office of inspection contains twenty inspectors who have general oversight of all the work. They see just what work is being done and the methods employed. When it is called for they give advice, although they are not authorized to issue orders. They make all reports to the Forester.

The office of law gives *advice* to the service on all legal matters, it helps to prosecute the offenders against the forest regulations, compiles forest laws and attends to the problems of ownership, taxation, and protection.

The office of publication and education has charge of the editorial and educational work of the Service.[1] It is divided into five sections, silvics, review, information, education, and printing. The section of silvics makes field investigations and studies from other sources, the habits and behavior of the trees in the forests,

[1]All the publications of the department of Forest Service including maps, photographs and lantern slides, are for sale or for free distribution. Any teacher may, upon application, receive all publications in any department of forestry as they are issued. Information with regard to publications may be had by addressing the Forester, Washington, D. C.

and systematically organizes all such data. The section of review makes technical and literary reviews of all the proposed publications. The section of information makes brief reports of the progress of different branches of the work of the Service. It issues a monthly program of the field projects and writes articles on forestry, especially that done by the government. The section of education teaches the principles and lessons of forestry by means of lectures, addresses, school instruction and through civic, industrial, and other associations. The section of printing publishes forms and manuscripts for the Service and keeps all necessary record of the printing work.

The Office of Dendrology makes studies of the natural history of trees, has charge of the forest library and photograph collection, and the forest exhibits. The dendrological studies comprise the making of accurate forest maps of the distribution of the species in the United States, giving the extent, composition and resources of the forests. The photographic collection contains twenty thousand pictures and about three thousand slides illustrating the work of the Service and the forest conditions. The exhibits are intended to arouse the interest of the public in forestry.

The Office of Grazing is one of the most important. It is so managed that the grass and forage is protected from overuse and the stockmen are protected from unfair competition. The different kinds of stock are handled separately and often the range is divided among the different stockmen. The office has to determine the positions available, usually open parks above timber line or parts of forests containing forage. It also has to decide the length of the period of occupation and the fees for permits. In 1908, twenty-four thousand permits were issued and the revenue received amounted to $960,000.

The Office of Record is in charge of the Special Fiscal Agent and is in three sections which take care of the accounts, purchase of supplies, and maintenance of the Office of Equipment.

The Reserve Force is perhaps the most important of all, for it is right on the field and is responsible for the final working out of the plans. At the beginning of the year 1909, there were fifteen hundred officers on duty. The force consists of forest supervisors, rangers, lumbermen and guards. Each forest is directly in charge of a supervisor who is usually selected for his practical knowledge of lumbering and grazing. He has an assistant of sound technical training, who prepares working and planting plans and investigates the behavior and the uses of trees, wood

preservation, and like matters. The rangers must be sound and able-bodied men capable of strenuous and diversified tasks. They have the patrol for fire, each ranger having an area of about 120,000 acres to watch. They must estimate, survey and mark timber for sales and supervise the cuttings. They issue minor permits and see that the regulations are enforced. They are helped by deputy and assistant rangers, who each have a definite district in charge. In the patrol for fire these rangers are greatly assisted by good roads, constructed for their use, and by telephone lines connecting the stations. The lumbermen see that the rules for logging are observed, and the planting assistant raises and cares for young trees. All these offices are obtained by examination except that of supervisor which is usually filled by promotion. The salary ranges from $2,500 for supervisors to about $800 for assistant rangers or guards.

The Office of Forest management is not much less important for it has the management of all the national forests and the coöperation with state and private forestry work. It is divided into three sections, timber sales, inspection, and coöperation. The section of timber sales has charge of all the timber from the reserves. It prepares working plans in advance, for all the sales are carried out under contract. The buyer is not limited unless there is danger of destroying the forest or establishing a monopoly disadvantageous to others. The contracts provide for the removal of dead and ripe timber, the care of young growth and the leaving of seed trees for reproduction; they insure careful logging and safeguards against fire. The period of sale is limited to five years, and a certain amount of timber must be taken out each year. In 1908 there were nearly 400,000,000 board feet sold, bringing receipts amounting to $750,000. The section of inspection sees that the regulations of the contracts are faithfully carried out.

The section of coöperation supervises the work of assistance to state and private owners of forest tracts. In the state coöperation, it makes examinations of the forest conditions for the states wishing it and outlines policies for them. It sometimes goes so far as to make accurate maps, estimate the amount of timber and draw up plans for management. The aid and advice of the Service may be obtained by any private owner wishing assistance in the management of his tract. Forest experts are sent out to make an examination of the land and to advise lines of action. If more detailed assistance is wanted, a party of men is sent

out, who calculate the stand of the whole lot and ascertain the rate of growth. After studies of reproduction, fire, grazing, and so forth, are made, plans are drawn up which will enable the owner to derive the fullest benefit from his land.

The Office of Forest Extension is organized under two main heads; one has charge of the planting on the reserves, and the other gives advice and assistance to private owners. Examinations are made of the forest covering at the sources of streams, and plans are made for reënforcing the deficient shelters. Many cities in the West depend for their water supply on the streams whose sources are among the national forests. The Forest Extension Office makes examinations of all such sources with a view to protecting and improving the water. But there are still other places where trees are needed, on hillsides and on irrigated land, for example. It has been estimated that there are at least 65,000,000 acres of land in the United States which are capable of growing only trees. The Forest Service is making an effort to cover these barren tracts. There are six permanent, reserve planting stations at San Gabriel, Dismal River, Pike's Peak, Santa Barbara, Gila River, and Salt Lake reserves. Yellow and jack pines have been found to be the most successful, although Scotch and Norway pines, red fir, and cedar are being tried. To a limited extent the Service is willing to plant, free of charge, for small land owners, public and educational institutions, and branches of the government. The same is done with reasonable charge for corporations or large land owners. Tree planting is especially encouraged in the irrigated lands.

The last office in the organization of the Forest Service is that of forest products. It is divided into four sections, forest measurements, wood preservation, wood chemistry, and wood utilization. The section of forest measurements makes computations and measurements of the forests and organizes the statistics and data of all branches of the force. It makes maps, drawings and diagrams of all the forest types to be found. The section of wood preservation determines by experiments the most economical way of handling and treating wood. It is ready to coöperate with anyone in this matter. It has recently aided Minneapolis in determining the best wood for paving block. The section of wood chemistry makes chemical analysis of such matters as preservatives, paper pulps, wood distillation, and the chemical changes in water seasoning. It has a laboratory at Yale and also at Boston. The section of wood utilization

studies market conditions and transportation. It publishes statistics of the wood manufacturers and fixes a basis for the grading of wood. In fact, it does everything to help the growers and buyers of wood to get the greatest possible profit for their goods.

Though the United States was one of the last countries to engage actively in forestry, it is now on its way, as we have seen, to keep its rich supply of wood from annihilation, and to continue on its prosperous course. The Forest Service is gaining more and more the confidence of the public. The settlers among the national forest lands realize that the protection and generous treatment that they receive amply overbalance the few restrictions imposed. The stockmen come to depend on these publicly owned ranges and find the security given them by the government is of inestimable advantage. The forestry movement certainly deserves the support of every loyal citizen as the only solution of the problem of our wood supply.

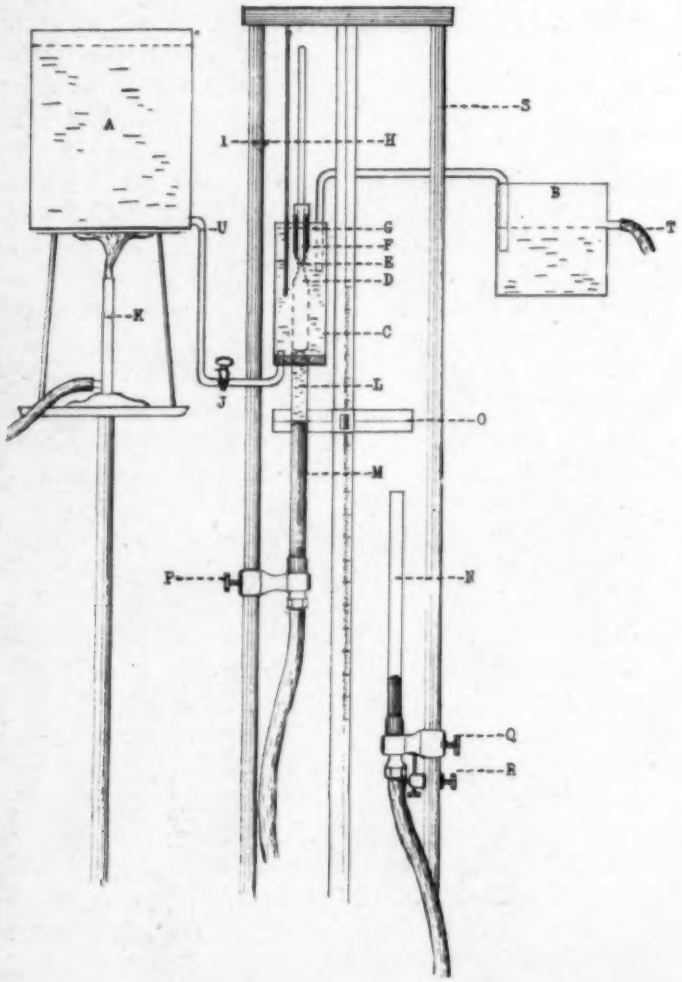
TO DETERMINE THE VAPOR TENSION OF A LIQUID WHICH DOES NOT COMBINE CHEMICALLY WITH MERCURY.

By F. W. Moody,
Soldan High School, St. Louis, Mo.

A very satisfactory method of determining the vapor tension of a liquid which does not combine chemically with mercury, and at temperatures between zero and one hundred degrees Centigrade, is an adaptation of a Boyle's Law piece manufactured by Wm. Gaertner & Co., the method of measurement being very similar to that used in the constant volume air thermometer. The part of the piece constituting the chamber in which the vapor is confined is of our own design and is very simple in construction. This will be readily understood by the following description and reference to the accompanying diagram.

A piece of glass tubing of the same size as the open tube N was heated until a contraction was formed and then a glass stopper in the form of a heavy glass rod was ground into this contraction so that an air-tight connection was formed. The rod was then set into the socket P, connecting with the open tube by means of a piece of tubing used in the Boyle's Law experiment. The tube is shown in place at M. E is the contracted point and H the rod serving as a stopper. The tube extends above the contraction to a height of about five centimeters. Over the upper part of this tube and extending eight centimeters below

the contracted point is placed a larger piece of glass tubing C, five centimeters in diameter, fitted with a water tight stopper at the bottom through which tube M passes, and through which another smaller tube leading from the reservoir A also passes. This serves as a constant temperature chamber, water at any desired temperature being let in from A and being siphoned over into the second reservoir B, provided with an outlet at T so that the level of the water in C is always kept uniform with that in B. The tube leading from A is provided with a stop-cock J which regulates the flow of water from A into C. I is a thermometer for determining the temperature of the water in the water jacket.



In setting up the piece the mercury in the tube M is brought well up to the contracted point by varying the height of N. The liquid whose vapor tension is to be determined is then poured into the top of the tube until sufficient is added to make a height of about two centimeters in the tube. The mercury is then lowered until the surface of the lighter liquid is slightly above the contracted point. The stopper is then placed in position and mercury poured into the cup formed above the point of contraction at F, the mercury serving to further aid in sealing the stopper. N is then lowered until the surface of the liquid falls to a point slightly above the upper part of the stopper in the bottom of C. The piece is then ready for use.

If all parts are at the room temperature at the beginning the height of the liquid in the tube above the dividing surface of the liquid and mercury can be determined and its mercury equivalent determined. Liquids being poor conductors of heat, the temperature of the mercury will not be appreciably affected by any change in the temperature of the surface of the liquid above. Any change in temperature of the vapor in the chamber D will cause corresponding change in pressure which may be read by noting the difference in the height of the mercury in M and N. A needle may be sealed in the tube M so that the surface of the mercury may always be kept in contact with this for a very delicate adjustment. The mercury equivalent of the lighter liquid having been once obtained, this will remain practically constant throughout the experiment whether that liquid expand or not, the only difference being due to the additional liquid changed into vapor, an amount too small for measurement. The piece is provided with a reflecting mirror, O, with vernier attached, to assist in making accurate readings and the socket supporting N is provided with a slow motion screw R which admits of careful setting. The vernier used reads to .1 mm. Corrections for surface tension can be applied very easily, both tubes being of uniform bore. When a reading is to be made water from the large reservoir A is allowed to flow through until the temperature becomes uniform. It will then remain so if the water is kept flowing until the reading is taken.

The convenience and simplicity of this piece, as well as the readiness with which it may be adapted for use with a large number of liquids, makes it very desirable for laboratory use with elementary students, and also furnishes a means of making fairly extensive investigations by more advanced students.

SPECIFIC GRAVITY OF LIQUIDS.

By E. J. Rendtorff,
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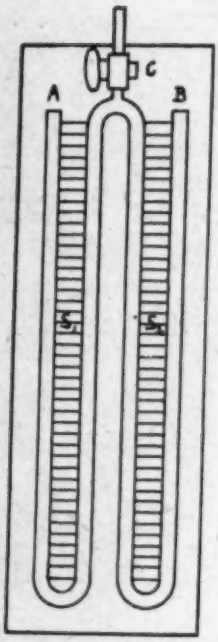


The determination of the specific gravity of liquids by Hare's method and by the balancing column method is quite universal. The standard forms of apparatus commonly used for these experiments are open to several objections.

In Hare's method the liquids are too exposed to dust and evaporation, while the lower end of measuring scale is soon apt to become corroded. In the balancing column apparatus it is necessary to add different amounts of liquid to obtain a series of readings.

A convenient form of apparatus which combines both methods is illustrated in the accompanying diagram. The tubes A and B, each some 50 cm. long and 1 cm. in diameter, have a stop cock, c, attached to the top of the central bend. Scales S_1 and S_2, made from meter sticks, just fit between the outer tubes. The entire apparatus is mounted on a convenient board and fastened to the wall of the laboratory. The left hand tubes are half filled with water and the others with the liquid whose specific gravity is desired.

By means of a short rubber tube the air below the stop cock can be either compressed or rarified and the liquids raised to their limit in either the outer or the central tubes. The specific gravity is the ratio of the water column to the liquid column. By adjusting the stop cock the heights of these columns can be altered easily and a series of determinations of specific gravity made with a minimum loss of time or danger of spilling the liquids over the laboratory table.

NUMBER OF PLANTS.

In 1909 there were 103 Portland cement plants in operation, an increase of 5 over the number working in 1908. Of these plants 21 were in Pennsylvania, 12 in Michigan, 10 in Kansas, 8 in Ohio, 7 in New York, 6 in Indiana, 5 in Illinois, and 5 in California.

THE COLLEGE AND THE SECONDARY SCHOOL.[1]

By William M. Butler,
Yeatman High School, St. Louis.

The last twenty-five years have been years of great change in school and college alike. A great increase of the number of students in school and college has taken place, and this has entailed corresponding changes in both institutions.

In the college, the tendency has been towards a rapid growth in the number of under-professors and instructors. There are relatively fewer full-professors, and much of the most important work of the college is now delegated to younger men, so that the full professors may have time for "original investigation," etc.

Is there any problem of the college more important than the question of what preparation entering students shall receive and how their qualifications shall be determined? To most secondary men, this seems a problem of grave importance, requiring on the part of the college man ripe experience and trained judgment.

That this is always possessed and always exercised is at least a debatable question.

Furthermore, the progress of the larger high schools in equipment, in management, in experience based upon dealings with thousands of pupils, in the possession of teachers of sound experience and good judgment has been quite as marked, as that of the college. Not infrequently, the city high school is larger than the small college, has a stronger faculty, and far better equipment. Many of our high schools offer salaries and working conditions so much better than the colleges that they secure some of the very best men and women to manage their classes.

When we take into account the character and training of secondary teachers in our larger high schools, their mature experience, their acquaintance with the student's needs obtained at first hand, their full knowledge of secondary requirements, it is certainly not too much to claim that they are far better equipped to determine what shall be taught in their schools, than are the college men, whose knowledge is necessarily much less complete, and much less reliable.

Already in many towns, the high school men have taken this matter into their own hands, and are deciding, without consulting

[1]Read at the annual meeting of the Missouri Society of Teachers of Mathematics and Science, at Kirksville, Mo., May, 1910.

the college, what shall be taught. This is a growing tendency and bids fair to become far more general.

If the college is to be left supreme in its field, it is not too much to insist that the secondary school is equally entitled to decide in its field what shall be done. The solution for the situation is to be found in the control exercised by associations, like the North-Central Association of Secondary Schools and Colleges, in which college and school alike are represented, and in which there is ample opportunity for mutual acquaintance and forbearance. Here is to be found the practical means of deciding the nature of the work of the secondary school, and its proper sphere.

The growth of the high school has made possible, in fact, has compelled specialization of its teachers, quite as much as in the college. In the larger high schools, the standard of training and attainments demanded of its teachers is fully equal to that of many of the colleges, and the knowledge of high school conditions possessed by these teachers is far more valuable than that of the college man.

The college man does not always appreciate the changes of recent years in high school management, instruction, equipment, and policy. The general introduction of manual training, of domestic science, of shops and laboratories, of commercial studies has utterly changed the face of the map, and has completely revolutionized the atmosphere of school work. In many schools, the great majority of the pupils are engaged in work offered in these new departments.

Changes of the radical and far-reaching nature here outlined make the relation of the school and the college more important than ever before. Some of the reasons which make this relation of such vital importance are now stated:—

(a) The tremendous increase in the number of high school and college students.

(b) The tendency, ever increasing, of the colleges to attempt independent adjustment of their relations to secondary schools.

(c) The wide difference in the importance of this relation in different communities, as some schools deal with but a single college; others, with many.

(d) The efforts of the college to dictate the details of secondary instruction, concrete instances of which are given, not as something deserving of condemnation in all cases, but as clear proof of the desire of the college to decide in detail how the school work shall be done.

(1) The University of Chicago requires that part of the required work in algebra shall not be done earlier than the third year of the student in school.

(2) Amherst prescribes that all work on which a certificate is offered shall have been done, or reviewed, in the last two years of the course.

(3) Some colleges apply different standards in algebra for pupils applying for admission on certificate, from what is prescribed for those applying for admission by examination. This difference is such that Principal Stearns, of Phillips Exeter, says that it is impossible to prepare students in the same class for the two sets of requirements.

(4) Wellesley demands that the work in physics offered by certificate shall have been done within 15 months of the date of entrance (in September). This aims to prescribe the time in the course at which this work shall be done, and is not a requirement of most colleges.

Innumerable instances of this dictation might be quoted, did time and space permit, but the only object in stating those above named has been to make clear the fact that the colleges have undertaken to decide, each in its own way, what the school should do and when it should undertake to complete its task.

(e) The efforts of a few of the colleges to make entrance examinations the sole test of a student's fitness for undertaking college work, as if an examiner could learn more of a student's preparation in two hours, than a competent schoolmaster and his faculty could ascertain in several years. The number of colleges which adhere to this plan is steadily lessening, and no doubt in a few years it will have been abandoned by all.

At present there are two plans of determining a student's fitness for college:—

(1) He may present himself for examination in a prescribed list of subjects, and in a few well-known colleges, this is the only method of admission.

(2) He may present a certificate of work done by an accredited school, whose right to grant such a certificate is variously determined:—

(a) By the college acting for itself alone, as at Cornell, Wellesley, etc.

(b) By virtue of the school's standing, as a member of an association of such schools, as in the North-Central Association of Secondary Schools and Colleges.

(c) By the examination of the school by the college examiner, as is done by many of the state universities.

Conversation last spring with the president of one of our best known colleges revealed that he felt there were serious objections to the plan of admission on certificate, and he named the following as suggesting themselves to him: The difficulty of deciding among the hundreds of schools, which ones were of such merit, as to deserve the right of certification; the even greater difficulty of knowing whether a school once granted this privilege was keeping up its standards; the difficulty of estimating the effect on school standards of changes in the faculty. Although he felt these were grave objections to the certification of students, yet he admitted freely that under the plan of examination followed in his own college almost 50 per cent of the entering students were conditioned in one or more subjects.

That the plan of entrance by examination alone has a marked effect upon the character of instruction in the schools which prepare students for institutions requiring it, is a well-known fact. Many, perhaps, most of these schools frankly devote a considerable portion of their last year's work to a formal review of sets of examination questions collected from all quarters by the instructors. Some schools even advertise that their students always "pass" the entrance examinations. That this policy tends to cramming pure and simple, and is a strong incentive to narrow work, omitting everything that does not chance to fall within the requirements of the current year, is beyond dispute.

The testimony of the dean of one of our oldest and best known colleges is emphatic. He says (see *Yale Alumni Weekly* for October 14, 1910) that 55 per cent of the boys who entered from private schools were conditioned, and that so far as entrance examinations go the boys from private schools seemed far better prepared than those from public schools. He adds that nevertheless, the high school boys do much better work in college.

Now, if even at as well-known a college as Yale, the entrance examination fails signally to test preparation for college work, is it not high time something better was devised as a means of testing worth and fitness?

It is still true, in many schools, that it is difficult to obtain competent teachers of mathematics and science. So long as these schools cannot offer to applicants, a fair salary, a secure tenure of office, and freedom from outside interference, good work cannot be done. Comparatively few teachers fail from knowledge of

their subject; many, from inability to impart and from lack of power to interest.

Is it not obvious that there should be a more uniform policy on the part of the colleges that would leave the schools as free in their own sphere, as the college now is, in its own? The present excessive variations in the college requirements, the grave uncertainty in regard to the character of the entrance examinations, and the frequent lack of school experience on the part of the examiner combine to render the present situation unbearable. Let us hope that some way out of the situation may be evolved that will leave the teacher free to teach, rather than to be judged alone by his power of successful cramming for certain "tests" whose scope and character is from long experience much better understood by some teachers, than by the general body.

NIPPORIUM.

Nipporium is the name of a new element whose discovery has been reported at the University of Tokio. Its atomic weight is given as 100. The new element occurs in a double silicate of nipporium and zirconium, forming yellow and red crystals hard enough to cut glass.

DRYING FURNACE BLAST.

A small amount of moisture in a cubic foot of air would ordinarily escape notice, but when a huge iron blast furnace uses an immense cubic footage of air in the course of a minute's time, the moisture content is sufficient to seriously affect the temperature of the smelting zone. Devices for the refrigerating of air for the blast furnace, in order to dry it, have been introduced with surprising results. In a plant near Pittsburg, the output of iron was raised by this method from 358 to 447 tons per 24 hours, with a saving of 421 pounds of coke per ton of iron produced. There is also a saving in the amount of air used and in the horsepower of the blowers.

STONE FOUNDATIONS ATTACKED.

Certain salts found in the recent soils of arid regions are under investigation by the Colorado State Geological Survey, and have been found to attack stone and brick work, mortar and cement. In some buildings in Denver bricks three or four feet from the ground have been entirely eaten away by water carrying these salts in solution. The common kinds are hydrous sulphates of lime, potassium and magnesium, and the latter especially is active in disintegrating Portland cement. The experiments of the survey have shown that foundations can be protected by some of the dark hydrocarbons, and it is believed that the paraffins can be used for the same purpose for the portions of walls above the surface of the ground. The results of the investigation made by the survey will be given in a forthcoming report on the building stones of Colorado.

PROBLEM DEPARTMENT.

By E. L. Brown,

Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott St., Denver, Colo.

Algebra.

212. *Selected.*

Show that the difference between any integer and its cube is divisible by 6.

Solution by Effie Morse, Madison, Ind., and Hilda R. Stice, Petersburg, Ill.

Let x be any integer. We are to prove that x^3-x is divisible by 6.

Factoring, $x^3-x = (x-1)\ x\ (x+1)$. We observe that $x-1$, x, $x+1$ are three consecutive integers.

Now in every two consecutive integers 2 is a factor of one, and in every three consecutive integers 3 is a factor of one. Therefore in the product of three consecutive integers the factors 2 and 3 would invariably occur. Since 2 and 3 are prime to each other, x^3-x is divisible by their product.

213. *Proposed by H. T. Trefethen, Kent's Hill, Me.*

Each item of an account expressed in cents is some term from one or the other of the two series: 1, 7, 49, etc., or 2, 14, 98, etc. If the debit balance is \$729.26, what are the several items on each side of the account? (A fine example in "Scales of Notation.")

Solution by Wm. B. Borgers, Grand Rapids, Mich., and I. L. Winckler, Cleveland, O.

Changing 72926 cents to the scale of 7, we have 422420 cents.

$$\begin{aligned}422420 &= 2\times7+4\times7^2+2\times7^3+2\times7^4+4\times7^5\\ &= 2\times7+7^3-3\times7^2+2\times7^3+2\times7^4+7^5-3\times7^5\\ &= 2\times7-7^3-2\times7^2+7^3+2\times7^3+2\times7^4-7^5-2\times7^3+7^3\\ &= 14-49-98+343+686+4802-16807-33614+117649,\end{aligned}$$

each number of the right hand member being in the decimal scale.

The positive terms are the items on the debit side and the negative terms are the items on the credit side.

Geometry.

214. *Proposed by C. M. Hebbert, Westerville, O.*

The alternate sides of an inscribed quadrilateral intersect in P and in Q. If tangents PR and QS be drawn, show that $\overline{PQ}^2=\overline{PR}^2+\overline{QS}^2$.

I. *Solution by the Proposer.*

Let AB and DC intersect in P, AD and BC in Q. Draw PE perpendicular to QB. Prolong BE its own length to F, and draw PF. Clearly the triangles CDQ and CFP are similar.

$\therefore \dfrac{PC}{CQ}=\dfrac{FC}{CD}=\dfrac{BC+2BE}{CD}$, or $PC\cdot CD=QC(BC+2BE)=$

$CQ\cdot BC+2CQ(CE-BC)=2CQ\cdot CE-CQ\cdot BC$.

$\therefore PC\cdot CD+CQ\cdot BC=2CQ\cdot CE$ .....(1)

Now, $\overline{PQ}^2=\overline{CQ}^2+\overline{PC}^2+2CQ\cdot CE$ .....(2)

From (1) and (2) we have

$\overline{PQ}^2=\overline{CQ}^2+\overline{PC}^2+PC\cdot CD+CQ\cdot BC=CQ\cdot BQ+PC\cdot PD=\overline{QS}^2+\overline{PR}^2$.

II. *Solution by G. B. M. Zerr, Philadelphia, Pa., and I. L. Winckler, Cleveland, O.*

Let AD and BC intersect Q, BA and CD in P: O the center of the circle; E the intersection of the diagonals; PR the tangent from P; QS, QL the tangents from Q. Draw PQ, PE, and let PE intersect QO in F. The points P, L, E, F, S are collinear and PF is perpendicular to OQ (see solution of Prob. 75, Vol. X, No. 1, page 70).

$\therefore \overline{PQ}^2=\overline{PF}^2+\overline{QF}^2=\overline{PO}^2-\overline{OF}^2+(QO-OF)^2=\overline{PO}^2+\overline{QO}^2-2r^2=\overline{PR}^2+r^2$
$+\overline{QS}^2+r^2-2r^2=\overline{PR}^2+\overline{QS}^2.$

III. *Solution by H. E. Trefethen, Kent's Hill, Me.*

About P with radius = PR, about Q with radius = QS, describe circles. RR′ the polar of P passes through Q. Hence Q is on the radical axis of the other two circles. Therefore the three circles are mutually orthogonal and thus $PQ^2=PR^2+QS^2$.

IV. *Solution by Orville Price, Denver, Colo.*

Let AD, BC meet in Q, AB and DC meet in P.

About the $\triangle$ CDQ describe a circle cutting PQ in G. Join CG.

BCG+BCD+DCG=4 rt. angles. Also, BCD+DCG+BAD+DQG=4 rt. angles.

$\therefore$ BCG=BAD+DQG. $\therefore$ BCG+BPG=2 rt. angles. $\therefore$ the quadrilateral BCGP is inscriptible.

Now $\overline{PQ}^2=PQ\cdot PG+PQ\cdot QG=PC\cdot PD+QB\cdot QC=\overline{QS}^2+\overline{PR}^2$.

215. *Proposed by the Editor.*

Give a *direct* demonstration of the theorem, If in two triangles ABC and A′B′C′ $b=b'$, $c=c'$, $a>a'$, prove $A>A'$.

Solution by H. E. Trefethen, Kent's Hill, Me.

I. About A describe circles, one with radius AB =c, the other with radius AC = AC′ = b; also about B describe concentric circles, the inner with radius BC′ = a', the outer with radius BC =a. Let AB (produced if necessary) cut the circle AC at X. The point C is outside the circle BC′. X is within the circle BC′, since BX, being the difference between two sides of a triangle, is less than BC′, the third side. Therefore the point C′ on the arc XC<180° lies between X and C and angle XAC>angle XAC′ or A>A′.

II. *Solution by Orville Price, Denver, Colo.*

Of the sides AB, AC, let AB be the one not greater than the other, and from B measure off BG = B′C′ and adjacent to BA. Then draw BH = A′B′ = AB, and GH = A′C′ =AC, the vertices A and H being on opposite sides of BC.

The $\triangle$ BHG = $\triangle$A′B′C′. Since BA = BH, the $\angle$ BAH = $\angle$ BHA (1)

The $\angle$ BGH is acute, since the side BH is not the longest side of the triangle BHG.

Since HG and HC must both lie on the same side of a perpendicular from H to BC, HC>HG. $\therefore$ HC>AC.

Then in the $\triangle$ AHC, the $\angle$ HAC>AHC..... (2)

Subtracting (1) from (2), we have $\angle$ BAC > $\angle$BHC.

But $\angle$BHC > $\angle$ BHG. $\therefore$ $\angle$ BAC>B′A′C′, since $\angle$ BHG = $\angle$B′A′C′.

216. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

Construct a triangle given its altitude and the radii of the inscribed and circumscribed circles.

I. *Solution by Richard E. Krug, Milwaukee, Wis., and G. I. Hopkins, Manchester, N. H.*

Let the required triangle have AB for its base, and the side AC<CB. Through O, the center of the circumscribed circle, draw the diameter HG perpendicular to AB, H and C being on the same side of AB; let HG intersect AB in N. Draw CD parallel to AB, intersecting HG in C′. Let

M be center of inscribed circle. Draw EM perpendicular to AC, and MQ perpendicular to HG. Also draw CG, AG, AM.

$\angle AMG = \frac{1}{2}C+\frac{1}{2}A = \angle MAG$. $\therefore AG = MG$.

Triangles CEM and AGN are similar.

$$\therefore \frac{EM \text{ or } r}{GN} = \frac{CM}{AG} = \frac{CM}{MG} = \frac{CQ}{QG} = \frac{h-r}{GN+r}.$$

$\therefore h-2r : r = r : GN$.

Hence the following construction: With given radius R describe the circumscribed circle O. Construct GN, a third proportional to $h-2r$ and r. Draw the diameter HG and on this set off GN. Through N and perpendicular to HG draw the chord AB. On NH take $NC' = h$, and through C' draw the chord CD perpendicular to HG. AB is the base, and either C or D the vertex, of the required triangle.

II. *Solution by I. L. Winckler, Cleveland, O.*

Let ABC be the required triangle; I the center of the inscribed circle tangent to AC at F; R, r, h, the radius of the circumscribed circle, the radius of the inscribed circle, the altitude from C to AB, respectively; a, b, c, the sides of the triangle; and K the area.

Now $\frac{1}{2}ch=rs$, each being equal to K. $\therefore h = \frac{2rs}{c}$.

$$h-2r = \frac{2rs}{c}-2r = \frac{2r(s-c)}{c} = \frac{2(s-c)}{c}\cdot\frac{K}{s}.$$

Also $R = \frac{abc}{4K}$. $\therefore 2R = \frac{abc}{2K}$, and $2R(h-2r) = \frac{abc}{2K}\cdot\frac{2(s-c)}{c}\cdot\frac{K}{s} = \frac{ab(s-c)}{s}$.

Again $\overline{CI}^2 = \overline{CF}^2+r^2 = (s-c)^2+\frac{(s-a)(s-b)(s-c)}{s} = \frac{ab(s-c)}{s}$.

$\therefore \overline{CI}^2 = 2R(h-2r)$. That is, CI is the mean proportional between 2R and $h-2r$.

To make the construction, draw AB tangent to the given inscribed circle; draw MN parallel to AB and at a distance from it equal to h; find CI, the mean proportional to 2R and $h-2r$; with I, the center of the inscribed circle, as a center and a radius equal to CI draw a circle cutting MN at C; from C draw tangents to the circle and produce them to meet AB at A and B. Then ABC is the required triangle.

III. *Solution by the Proposer.*

Put p, r, R for the given parts and let K be the center of the circumcircle. On AK = R take $AP = p - r$, at P draw a perpendicular across AK, and about A with radius $= \sqrt{2R(p-2r)}$ draw an arc cutting the perpendicular in O and O'. O or O' is the center of the incircle. Then either (1) draw the incircle with radius r, the tangents AB, AC and BC, or (2) draw AOE, OS perpendicular to the diameter EF, on SE take $HS = r$, draw BHC perpendicular to EF, and join AB, AC. ABC is the required triangle.

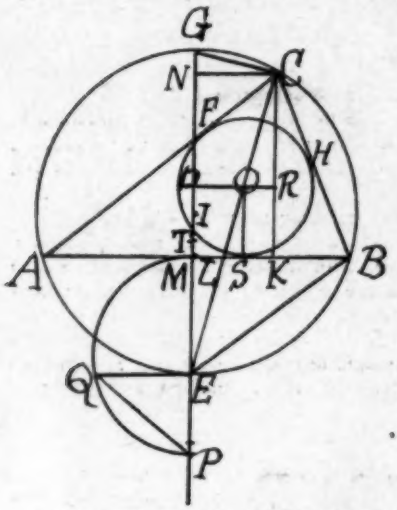
Proof. Draw $AD = p$ cut at Q by SO produced. Then $AP = AQ = p - r$, $PK = R + r - p$.

$$\begin{aligned} AO^2 &= AP^2+OP^2 = AP^2+OK^2-PK^2 = AP^2-PK^2+OS^2+KS^2 \\ &= AP^2-PK^2+OE^2-ES^2+KS^2 = AP^2-PK^2+BE^2-ES^2+KS^2 \\ &= AP^2-PK^2+BH^2+EH^2-ES^2+KS^2 = (AP+PK)(AP-PK)+BK^2-(HK^2-EH^2)-(ES^2-KS^2) \\ &= 2R(p-r)-R(HK-EH)-R(ES+KS) = 2R(p-2r). \end{aligned}$$

Therefore AO is a mean proportional between R and $2(p-2r)$.

IV. *Solution by G. B. M. Zerr, Philadelphia, Pa.*

Let I be the center of circumcircle. Take ET = diameter of incircle, and draw EQ perpendicular to ET and = ½ET; also take TP = the given altitude. Through P, Q describe the semicircle PQM and draw AMB parallel to QE. Take MN = TP, draw NC parallel to AB and join C to A and to B. Then ABC is the required triangle. Join E to C and to B, and take EO = EB, giving O as center of the incircle. Draw the perpendiculars OS, CK, and join C to G. Also draw ROD parallel to AB. The altitude and circumradius are determined, and we have to prove OS = EQ.



In the similar triangles EBL, ECB we have

EL : EB = EB : EC or

EO—OL : EO = EC—CO : EC,

since EO = EB.

∴ OL : EO = CO : EC or EC : EO = CO : OL = CR : OS.

Hence EC = (EO·CR)/OS. In the similar triangles EDO and ENC ED : EO = EN : EC or EM+OS : EO = EM+CK : EC or (EO·CR)/OS.

∴ EM = OS(CK—CR)/(CR—KR) = $\overline{OS}^2$/(CK—2OS).

But EM = $\overline{EQ}^2$/EP = $\overline{EQ}^2$/(CK—2EQ). ∴ OS = EQ.

CREDITS FOR SOLUTIONS RECEIVED.

Geometry 210. H. C. Feemster, L. E. A. Ling, A. W. Rich, J. M. Townsend, I. L. Winckler, G. B. M. Zerr. (6).

Geometry 211. E. L. Brown, H. C. Feemster, A. W. Rich, I. L. Winckler, G. B. M. Zerr. (5).

Algebra 212. T. M. Blakslee, Wm. B. Borgers, W. F. Burns, T. Hollie, G. I. Hopkins, Effie Morse, Orville Price, Hilda R. Stice, H. E. Trefethen, I. L. Winckler, G. B. M. Zerr. (11).

Algebra 213. Wm. B. Borgers, I. L. Winckler, H. E. Trefethen, G. B. M. Zerr. (4).

Geometry 214. C. M. Hebbert, H. E. Trefethen, I. L. Winckler, G. B. M. Zerr. (4).

Geometry 215. Orville Price, H. E. Trefethen (2 solutions), G. B. M. Zerr. (4).

Geometry 216. G. I. Hopkins, R. E. Krug, H. E. Trefethen, I. L. Winckler (2 solutions), G. B. M. Zerr. (6).

Total number of solutions, 40.

PROBLEMS FOR SOLUTION.

Algebra.

224. *Proposed by Grace E. Shoe, Denver, Colo.*

Solve: $x^{\frac{1}{3}}+x^{\frac{3}{5}}=(2^6+2^{-6})x\sqrt[5]{x^{2/3}}$ (Hawkes' Advanced Algebra, Page 79, Ex. 26.)

225. *Proposed by E. L. Blackshear, Prairie View, Texas.*

Prove: Any number which is a perfect cube has a cube root which is some multiple of six, plus the remainder left after dividing the cube by six.

Geometry.

226. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

If from any point in either side of a right triangle, a line is drawn perpendicular to the hypotenuse, the product of the segments of the hypotenuse is equal to the product of the segments of the side plus the square of the perpendicular.

227. *Proposed by Norman Anning, Challiwick, B. C., Canada.*

A, B, and C are any three points in a plane. With center B a circle-quadrant CQ, with center A a quadrant QR, with center B a quadrant RS, and with center A a quadrant ST are described, all in the same direction of turning. Prove that T and C coincide.

228. *Selected.*

Prove that the circumcircle of a triangle bisects each of the six segments determined by the in-center and the three ex-centers of the triangle.

SCIENCE QUESTIONS.

BY FRANKLIN T. JONES,

University School, Cleveland, Ohio.

Readers of SCHOOL SCIENCE *are invited to propose questions for solution —scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

34. *Proposed by Chas. H. Korns, Bradford, Pa.*

Two floors are 27 feet apart. A man weighing 200 pounds ascends from the lower to the upper (a) by a flight of stairs, each step one foot high and one foot deep, walking at a uniform speed; (b) by the same flight of stairs with a uniform acceleration of 3 feet per second per second both vertical and horizontal; (c) by the same flight of stairs, starting at rest and having a uniform acceleration of 3 feet per second per second both horizontal and vertical for two seconds, when the speed becomes uniform at the rate attained; (d) by a vertical ladder at uniform speed; (e) by the same ladder with a uniform acceleration of 3 feet per second, having started at rest. What is the work done in each case?

35. *Proposed by Chas. H. Korns, Bradford, Pa.*

Why is the shell of a boiled egg more easily removed after submersion in cold water?

Solutions.

32. What difference would there be in the weight of a perfectly air-tight bird cage, depending on whether the bird were sitting on the perch or flying about?

Solution by Chas. H. Korns.

There would be no difference in the weight when the bird perched or flew. The air which supports the bird rests on the bottom of the cage. If

the same cage had no top the same would hold. If it had no bottom there would still be no difference in weight. In this case the flight of the bird would tend to produce a vacuum just under the top, and the air above the cage would press downward with a force equal to the weight of the bird. If both top and bottom were removed there would be a difference equal to the weight of the bird.

33. *From an examination paper of Lake View High School, Chicago.*

A bullet, the mass of which is 30 gm., and which is moving with a speed of 3×10^8 cm. per second, strikes a piece of wood and penetrates 10 cm. What is the wood's resistance to penetration? Give answer in joules.

Solution by Chas. H. Korns.

K.E. $= \frac{1}{2}mv^2 = \frac{1}{2} \cdot 30 \cdot (3 \times 10^8) = 450{,}000{,}000$.

$\therefore$ K.E. 450,000,000 ergs $=$ 45 joules.

Since 45 joules cause a penetration of 10 cm., 4.5 joules would cause a penetration of 1 cm. Or the resistance of the wood to penetration is 4.5 joules to the centimeter.

The following is the first paper set under the new syllabus. This syllabus was prepared by a committee made up of secondary school teachers only.

College Entrance Examination Board. Physics—Two Hours.

[1910.]

A teacher's certificate covering the laboratory instruction must be presented at the time of the examination.

Answer ten questions as indicated below. No extra credit will be given for more than ten questions.

GROUP A. Omit one question from this group.

1. Explain the meaning of the terms, force, work, energy, power. Explain how the simple pendulum, when swinging, illustrates change of energy of one kind into energy of another kind.

2. A block of silver, apparently solid, is in reality hollow. Its weight in air is 336 grams, and its weight in water is 284 grams. What is the volume of the cavity? (The specific gravity of silver is 10.5.)

3. A body weighing 5 pounds rests on an inclined plane the length of which is 10 feet, the height 6 feet, and the base 8 feet. How great is the pressure which the body exerts perpendicular to the plane? Neglecting friction, find how much work must be done to move the body from the bottom to the top of the plane.

4. Show by a diagram how two single pulleys may be so arranged as to afford a mechanical advantage of 2. If an effort of 3.25 lbs. must be used with this device in order to raise a weight of 4 lbs., what is the efficiency of the machine?

GROUP B. Omit one question from this group.

5. How does sound differ from light in respect to—

(a) the manner of propagation,

(b) the nature of the medium required,

(c) velocity?

6. Find the velocity of sound in air if a tuning-fork making 68 vibrations per second has its sound most strongly reinforced when held over an air-column 1.25 meters long.

GROUP C. Omit one question from this group.

7. A shallow dish of water at the temperature of the room is placed under the receiver of an air-pump and the air is rapidly pumped out. No other source of heat or cold is employed, but presently, as the process of exhaustion is continued, the water is seen to boil, and shortly after that,

to freeze. Explain carefully both the boiling and the subsequent freezing.

8. Explain accurately what is meant by the statement that the coefficient of expansion of air is 1/273. The volume of a body of air at —10° C. is 200 cu. cm. The pressure remaining unchanged, what will be the volume of the air at 100° C.? Given 200 cu. cm. of gas at 760 mm. pressure, at what pressure would its volume be 150 cu. cm., the temperature remaining unchanged?

9. In order to determine, approximately, the temperature of a furnace, a platinum ball weighing 100 grams is placed in the furnace and after a time removed and dropped into 400 grams of water at 0° C. The temperature of the water rises to 10° C. Calculate the temperature of the furnace. (The specific heat of platinum, for this range of temperature, is 0.038.)

GROUP D. Omit one question from this group.

10. Draw a diagram of a concave mirror, indicating the principal axis, a secondary axis, the center of curvature, and the principal focus.

Indicate a point on the principal axis, the image of which formed by the mirror would be real, and another point the image of which would be virtual.

11. The lens in a camera has a focal length of 15 inches. How far from the lens must an object be placed in order that a clearly defined image of it may be thrown on a sensitive plate which is 16 inches from the lens?

12. Why is it difficult to match certain colors by lamp-light so that they will agree by daylight?

GROUP E. Omit one question from this group.

13. What are the essential parts of a voltaic cell? What are the defects of a simple cell, and how may they be corrected?

14. Five 16-candle-power incandescent lamps, each having a resistance, when hot, of 220 ohms, are arranged in parallel on a 110-volt circuit. Calculate

(*a*) the total current taken by the lamps,

(*b*) the watts consumed by one lamp.

15. Describe the method by which a current of electricity may be induced in a coil of wire and indicate the direction of the current induced

(*a*) by means of another current,

(*b*) by means of a magnet.

MEANING OF "REDUCTION."

The use of the term "reduction plant," in speaking of works devoted to the production of metals from ores, is not favored by metallurgists for the reason that the term "reduction" has a definite scientific application more restricted than that which conveys the general and popular meaning of "reducing" ores to bullion. In a chemical sense the term refers to the reduction of a compound from a higher to a lower degree of oxidation. A strictly metallurgical definition is that of a reaction in which a metal is reduced from its compound by means of a reducing agent. A "reduction plant," popularly so-called, may employ oxidation processes, which are not reducing processes.

WORLD'S IRON SUPPLY.

A report presented or compiled by the International Geological Congress places the known iron ore reserves of the world at 22,408 million tons, of which 12,032 million is in Europe, 9,855 million in America, 260 million in Asia, 136 million in Australia and 125 million in Africa. Tre iron content of this ore is almost 10,192 million tons, of which 5,154 million tons are represented by the iron ore of America.

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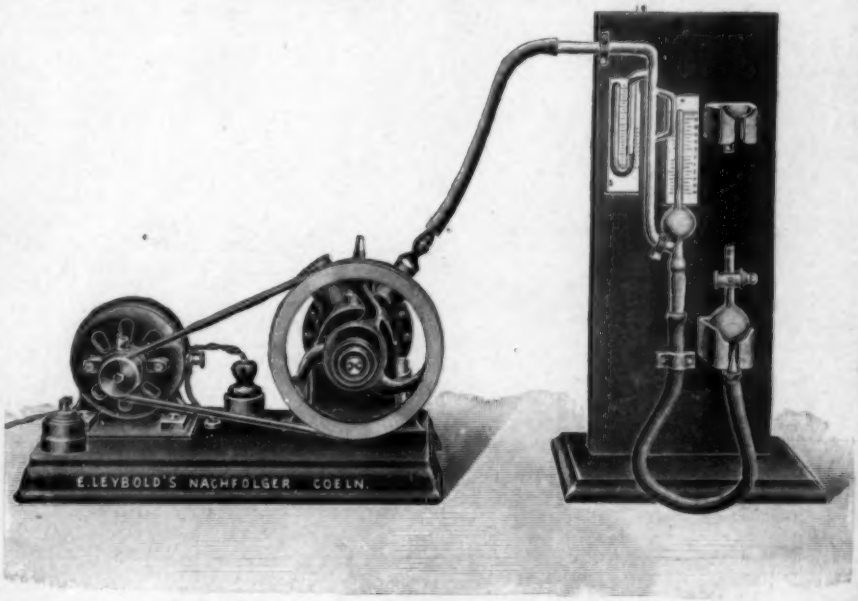

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ARTICLES IN CURRENT MAGAZINES.

American Naturalist for October: "Variations in Urosalpinx," Dr. Herbert E. Walter; "Nuclear Phenomena of Sexual Reproduction in Gymnosperms," Charles J. Chamberlain; "Nuclear Phenomena of Sexual Reproduction in Angiosperms," D. M. Mottier; "Shorter Articles and Discussions," Dr. Max Morse.

Auk, The for October: "The Canvas-back in Massachusetts," S. P. Fay; "Notes on the Birds of the Sunken Lands of Southeastern Missouri," Arthur H. Howell; "Some Rare Wild Ducks Wintering at Boston," Horace W. Wright; "A Hermit Thrush Study," Norman McClintock; "Wild Life of an Alkaline Lake," Florence M. Bailey; "Some Early Records of the Passenger Pigeon," Albert H. Wright; "The Brewster Warbler in Massachusetts," John W. Sherman.

Bird-Lore for September-October: "Notes on Attracting Birds," John C. Phillips; "Wing-Bars as Field-Marks," Edmund J. Scrojer; "Must Wrens be Taught Nest Building?" Craig S. Thoms; "A Record of the Outcome of Seventy-five Birds' Nests," Raymond H. Wheeler; "A Day With the Birds of Southern Arizona," Stephen S. Visher; "Notes on Birds in the Florida Keys," Mrs. Lucas Broodhead; "The Migration of North American Sparrows," W. W. Cooke.

Condor, The for September-October: "The Discovery of the Nest and Eggs of the Gray-crowned Leucosticle," Milton S. Ray; "An Irrigated Ranch in the Fall Migration," Florence M. Bailey; "Nesting of the Gray-headed Junco," Robert B. Rockwell.

Journal of Geology for September-October: "An Experimental Investigation into the Action of Differential Pressure on Certain Minerals and Rocks, Employing the Process Suggested by Professor Kick," Frank D. Adams; "Dissocophus Cape," S. W. Williston; "A Mounted Skeleton of Platecaspar," S. W. Williston; "Older Drifts in the St. Croix Region," Rollin T. Chamberlin; "'Rock Glaciers' or Chrystocienes," J. B. Tyrrell; "On a Peculiar Cleavage Structure Resembling Stretched Pebbles, near Ellijay, Georgia," W. C. Phalen.

Physical Review for November: "A Method of Measurement of the Peltier E. M. F. in Absolute Units," Harold C. Barker; "A Method of Measuring the Intensity of Sound," W. M. Boehm; "A Determination of the Correction for the Open End of a Cylindrical Resonator," W. M. Boehm; "A Proposed Method of Calibration of Optical Pyrometers," G. A. Shook; "Some Phosphorescent Salts of Cadmium with Sodium," C. W. Waggoner; "A Study of the Short-Time Phosphorescence of Certain Compounds," Carl A. Zeller; "Studies in Luminescence. XII. The Absorption of Alcoholic Solutions of Eosin and Resorufin," Edw. L. Nichols and Ernest Merritt; "Studies in Luminescence. XIII. The Specific Exciting Power of the Different Wave-Lengths of the Visible Spectrum in the Case of the Fluorescence of Eosin and Resorufin," Edw. L. Nichols and Ernest Merritt; "Infra-Red Absorption Spectra," Willibald Weniger; "A Study of Some of the Elastic Properties of a Platinum-Iridium Wire," L. P. Sieg; "The Effect of Temperature on Fluorescence and Absorption," R. C. Gibbs.

Popular Astronomy for November: "What is the Ether?" Owen Ely; "Some Recent Discoveries in Cosmical Evolution," T. J. See; "Drifting of the Sun's Family," Arthur K. Bartlett; "Early Observations of the South Polar Cap and Belts of Saturn," H. C. Wilson; "The Distribution of Nebulæ and Globular Star Clusters," E. A. Fath; "The Relation between the Separation and the Magnitude of Visual Binary Stars," R. G. Aitken; "New Double Stars and Double Star Work," E. D. Roe, Jr.

Psychological Clinic for October: "What is Meant by Retardation?" Lightner Witmer; "The Boy in the Private School," Charles Keen Taylor; "The Training of a Case of Infantile Stammer," Clara Harrison Town; "The Bright Child," Ella Frances Lynch.

Sibley Journal of Engineering for October: "The Manufacture of Portland Cement," J. R. Bolgiano; "The Practical Application of Automatic Telegraphy," Romyn Hitchcock; "Some Technical Features of Telephone Engineering," R. M. Ferris and Dr. Jewett.

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REPORT OF THE NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The thirty-ninth meeting of the association was held Saturday, October 22, 1910, at Boston University, Boston, Mass. After the reading of the annual reports of the secretary and the treasurer, the report of the committee on current events was read by title to be published in the printed report of the meeting. Mr. George Cowen reviewed Mr. R. P. Williams's "Essentials of Chemistry," and Mr. W. Segerblom reviewed the "Chemist's Pocket Manual," by R. K. Meade.

The opening address was by Professor H. W. Morse of Harvard University on "The Experimental Basis of the Theory of Radio-activity." He reviewed the work of Rutherford, Soddy, and the Curies, and discussed relations between the decomposition of radium emanations, the passing of an electric current through a gas, and the absorption spectra at low temperatures. Mr. Walter G. Whitman of the Salem Normal School described some interesting new experiments on the analysis of respired air, the percentage of carbon monoxide in illuminating gas, and the combustion of iron in oxygen. The last address of the session was given by Professor Latham Clark of Harvard University on "Some Phases of the German Chemical Industry." His extremely interesting and eye-opening talk dealt with the economical production of carbon dioxide with the greatest saving of material and energy, using this as an example of the German method of utilizing waste.

An impressive part of the business session was the recognition of the recent death of two of the members of the association, Miss M. G. Farwell, and Mr. L. O. Towne. On motion from the floor the members of the association paid their respects to the memory of these two members by raising and standing silent a few moments.

It was voted to incorporate the association under the laws of the state of Massachusetts; also to establish a committee authorized to receive and care for text-books, specimens, and other illustrative material that may be donated for the use of the association. The following officers were elected for the ensuing year: President, Mr. F. C. Adams; Vice-President, Mr. C. W. Goodrich; Secretary, Mr. E. S. Bryant; Treasurer, Mr. A. M. Butler; Executive Committee: Professor F. L. Bardwell, Mr. H. Bisbee, and Mr. G. A. Cowen. The meeting adjourned at twelve-thirty.

WILHELM SEGERBLOM.

KANSAS ASSOCIATION OF MATHEMATICS TEACHERS.

The Kansas Association of Mathematics Teachers held their annual meeting in the audience room of the Baptist Church, Friday, October 21, at 2 P. M., the president, Mr. A. M. Bogle of Kansas City, presiding.

The central thought, "What to Emphasize and What to Eliminate in High School Mathematics," was carried out in the following program:

"Geometry, from the Standpoint of the High School," by Miss Eleanora Harris of Hutchinson, who said in part: "One prominent reason for trouble in geometry is that the teacher does not use good judgment at the beginning; makes the subject too hard or too easy to attract." Among the things to emphasize she advised correlation, accurate construction, many originals and many numerical problems; loci problems, historical facts and free use of oral work, models, and diagrams. Among the things to eliminate she suggested problems or proofs too difficult for the class, too strict adherence to logical order, incommensurable cases, and all but a cursory treatment of limits.

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Following this, J. W. Young of the University of Kansas spoke on the same subject from the standpoint of the university. He advised teachers to emphasize whatever leads pupils to *think*, pointing out that one can get information without thinking, but cannot think without information. Allow pupils to think in their own way if necessary, not insisting on strictly formal proofs. Among the causes of poorly prepared students are the text-book and the artificial formal demonstration. Mr. Young emphasized the desirability of the early introduction of functionality both in algebra and geometry.

In the discussion following these two papers it was found that many think the theorem should be committed to memory, while others think only substance need be learned. Some thought even definitions need not be learned.

Professor E. R. Hedrick of the University of Missouri then gave an address on "Selection of Topics for Elementary Algebra," in which he said that nothing need be taught in algebra that could not be justified in itself—if given only for help in something else, it might be omitted. Problem solving is justified in itself only if applied to problems that need solving. The study of variable quantity and the acquisition of power to control or know variable quantity resulting in the habit of functional thinking, is the real reason for studying algebra. Formal manipulation, such as cube root, difficult square root, hard fractions, radicals, and long division, have no place in elementary algebra. Summing up Mr. Hedrick said: "The life of algebra is variability, the spirit dependence of one quantity on another, and the tools, algebraic relations stated in symbols."

Miss Ella Woodyard of Kansas City, Kan., then told of "An Experiment in Rearranging the Order of Topics in First Year Algebra," which was very interesting and is proving a successful plan.

The nominating committee reported for officers for the ensuing year: President, Professor C. H. Ashton, University of Kansas; for Secretary-Treasurer, Miss Eleanora Harris, Hutchinson, Kan.

EMMA HYDE, Secretary-Treasurer.

THE VOLATILE MATTER OF COAL.

This is the title of the first bulletin to be issued by the new Federal Bureau of Mines. The authors, Horace C. Porter and F. K. Ovitz, conducted their investigations at the Pittsburg station while it was under the Technologic Branch of the Geological Survey, the work being a continuation of the fuel investigations begun several years ago at the Louisiana Purchase Exposition, St. Louis, Mo. The results obtained at that plant showed that the work of determining the fuel values of the coals and lignites in the United States with a view to increasing efficiency in their utilization would be incomplete if it did not include systematic physical and chemical researches into the processes of combustion. Hence in their later investigations the authors carried on such researches, concentrating attention on those lines of inquiry which promised results of greatest economic importance. This bulletin is therefore a report on an investigation of the volatile matter in several typical coals—its composition and amount at different temperatures of volatilization.

Quoted directly the authors say: "The investigation has already shown that the volatile content of different coals differs greatly in character. The volatile matter of the younger coals found in the West includes a large proportion of carbon dioxide, carbon monoxide, and water, and a correspondingly small proportion of hydrocarbons and tarry vapors. The older bituminous coals of the Appalachian region yield volatile matter containing large amounts of tarry vapors and hydrocarbons, difficult to burn completely

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without considerable excess of air and a high temperature. Coal of the Western type, moreover, gives up its volatile matter more easily at moderate and low temperatures than that of the other type. The volatile matter produced at medium and low temperatures is rich in higher hydrocarbons of the methane type, such as ethane and propane, which contain a larger portion of carbon than is present in methane.

"These facts help to explain the difficulty of burning Pittsburg coal, for example, without smoke, the low efficiency usually obtained in burning high-volatile Western coals, the advantage of a preheated auxiliary air supply introduced over a fuel bed, and the advantage of a furnace and boiler setting adapted to the type of fuel used. They bear directly also on the question of steaming 'capacity' of coal for locomotives, the designing and operation of gas producers for high-volatile fuels, and the operation of coke ovens and gas retorts.

"The results show further that certain bituminous coals of the interior and Rocky Mountain provinces give promise of good yields of by-products of coking, notably ammonia and high candle power gas, comparing favorably in these respects with the high grade coking coals of the eastern province.

"They show also that inert, noncombustible material is present in the volatile products of different kinds of coal to an extent ranging from one to fifteen per cent of the coal."

The bulletin will be of interest to all users of fuel. It may be obtained by applying to the Director of the Bureau of Mines, Washington, D. C.

BOOKS RECEIVED.

Elementary Analysis, by Percy F. Smith and William A. Granville. Pages x+223. 14x20 cm. Ginn & Co., Boston and Chicago.

Bookkeeping and Business Practice, by Wallace H. Whigans, Crane Technical High School, Chicago and Oliver D. Frederick, Tuley High School, Chicago. Pages iv+142. 19½x24½cm. D. C. Heath & Co., Chicago and New York.

A Text-book on Advanced Algebra and Trigometry, by William C. Brenke, University of Nebraska. Pages vii+345. 15x23cm. The Century Company, New York.

Analytic Geometry, by N. C. Riggs, Carnegie Technical School, Pittsburg, Pages xi+294. 14x20 cm. $1.60 net. The Macmillan Company, New York.

Elements of Plane of Spherical Trigonometry, by David A. Rothrock, Indiana University. Pages xxv+246. 17x24 cm. $1.40 net. The Macmillan Company, New York.

Proceedings of the Fourteenth Meeting of the New York State Science Teachers' Association. Pages 126. 16x24 cm. University of the State of New York, Albany.

General Science Outline, by Percy E. Rowell, Gardena Agricultural High School, California. Pages 148. 16x22 cm. 65 cents, postage extra. Cummingham, Curtiss and Welch, San Francisco, Cal.

School Architecture and School Improvement, by Edward Hyatt, Superintendent of Public Instruction. California. Pages 152. 16x24 cm. 120 illustrations. State Printing Office, Sacramento, Cal.

BOOK REVIEWS.

Elementary Arithmetic, by D. A. Preston, Principal Public School No. 16½, Brooklyn, N. Y., and E. L. Stevens, Associate City Superintendent of Schools, the City of New York. Price 35 cents. 1910. The Macmillan Company.

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Something of real value to High School pupils. —*Edward C. Elliott, Professor of Education, University of Wisconsin.*

Practical because it is full of *useful problems.*—*L. Wayland Dowling, Asst. Professor of Mathematics, University of Wisconsin.*

A student will never need to ask the use of Geometry or to regret that he is spending his time on some dead science.—*Charles Leckrone, Manual Training School, Saint Louis, Missouri.*

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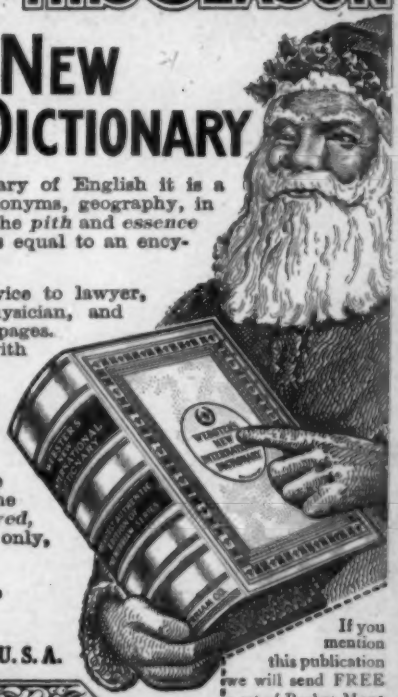

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This book is prepared for the third, fourth, and fifth years of the elementary school, and is the first of a series which will present a complete course in arithmetic for elementary schools. Some of the points to which attention is called are the following: Additive-subtraction; the condensation of the multiplication table; abundance of simple, direct, and easy problems carefully graded; figures in each of the four processes are used in the relative position found in actual computation, hence the child acquires notions of relation through visualization. H. E. C.

Practical Algebra, First Year Course, by Jos. V. Collins, Ph.D., Professor of Mathematics, State Normal School, Stevens Point, Wis. Pp. 301. Price 85 cents. 1910. American Book Company.

This First Year Course is a condensation of the Author's Elementary Algebra which was reviewed in the January, 1909, issue of this journal. In adapting the Elementary Algebra to the needs of first year pupils, some of the more difficult exercises and some chapters on advanced topics were omitted, while other sections were modified and simplified. The number of geometrical problems was increased. Some of the noteworthy features of the present volume are: the system of checking and proving results which is carried consistently through the book; clearness in presentation; the large number of practical problems; the historical notes; and the correlation with physics, geometry and other branches of mathematics. H. E. C.

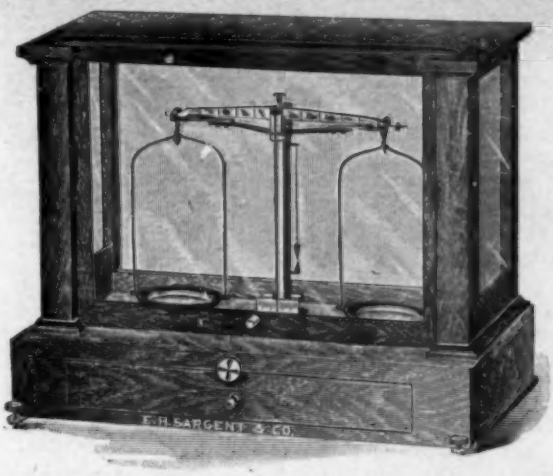
College Algebra, by S. C. Davisson, Sc.D., Professor of Mathematics in Indiana University. Pp. xiv+243. Price $1.50. 1910. The Macmillan Company.

The first one hundred and thirty-seven pages of the book include the topics of the usual high school course in advanced algebra, while the remaining pages deal with the topics of college algebra. But the first half of the book is a great deal more than a review of high school algebra. It is essentially a discussion of the elementary conceptions of algebra which is entirely lacking in most elementary text-books. In Chapter I there is a detailed outline of definitions and theorems leading to a development of the complete number system consisting of natural, rational, real, negative, and complex numbers. At each stage of the development the necessity for the extension is pointed out. Throughout the book the author emphasizes the need of training the student to express in his own language conclusions usually expressed by the use of symbols, and there are many translation exercises. The author's careful treatment and discussion of the fundamental conceptions of algebra makes it a valuable book of reference for the high school teacher.

It is the aim of the book to show the student that algebra consists of something more than the solution of problems; hence the proof and application of theorems has been emphasized while the number of problems is small. For a semester's work in college algebra as a preparation for work in pure mathematics this book may well find a place in many colleges, but it is doubtful if it is the best book for the man who is not to devote himself to mathematics. H. E. C.

Secondary School Mathematics, Book I, by Robert L. Short, Head of the Department of Mathematics, Cleveland Technical High School, and William H. Elson, Superintendent of Schools, Cleveland, Ohio. Pp. viii+182. Price $1.00. 1910. D. C. Heath & Co.

Book I covers a year's work in algebra and geometry; algebra through fractional equations and straight-line geometry to proportion. The text-book is the result of a successful endeavor to unite the various branches of mathematics in the work of the technical high school. It has been the aim to give the pupils a working knowledge of the underlying principles of mathematics and the ability to solve practical problems.



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In the algebraic work manipulation of complicated forms and long continued drill in handling literal expressions has been omitted. The need of thoroughly understanding the simple but important principles and processes has been emphasized, and drill is furnished by a good supply of simple arithmetical and geometrical problems. It is interesting to see that there are practical problems for girls as well as for boys. It would seem, however, that the importance of the graph as a tool in solving problems and checking results should be recognized in a book of this character. Only five pages are given to the graph; and the only use made of the graph is to represent and solve simultaneous equations, which is very much like building a steam-hammer to crack nuts.

The work in geometry is worth the careful study of every teacher. Constructions are made from the first; and when there is no figure given for a theorem, it looks as if the pupil would really have to use his pencil and compasses if he is to have a figure to study. The proofs are put in the equation form as far as possible, so that there is a close connection with algebra. In any school where there is little change of pupils during the year this book can be used; and it is to be hoped that text-books of this character will be tried out in many schools. H. E. C.

The Fourth Dimension Simply Explained, edited by Henry P. Manning, Ph.D., Associate Professor of Mathematics in Brown University. Pp. 251. Price $1.50. 1910. Munn & Company, 361 Broadway, New York.

"If you were a point and if you lived on a straight line you would be a one-dimensional man. You could move backward and forward only. You could not look up or down, nor from side to side. Your visible world would lie always in front of your eyes. You could see only the back of the man's head in front of you. You could never turn around and talk to the man behind you.

"If you lived on a surface you would be a two-dimensional man. In other words you would be a smear. You would slide around like quicksilver, but you would have no thickness. You could turn around and see the man behind you, but you could not look down nor up.

"The world in which we live is a world of three dimensions. It has length breadth and thickness. If the inhabitants of the two-dimensional world were to attempt to imprison you in a two-dimensional jail you could escape simply by stepping over the walls of your prison, and your two-dimensional jailers would never realize how you eluded them.

"If there is such a thing as a fourth dimension it would be impossible for us to incarcerate a four-dimensional criminal. He would step out of his jail and we would never know how he escaped. A hollow rubber ball could be turned inside out in the fourth dimension. A liquid could be poured into a completely enclosed hollow vessel in the fourth dimension."

Last year a friend of the *Scientific American* offered a prize of $500 for the best non-mathematical explanation of the fourth dimension. Of the two hundred and forty-five essays submitted, the prize-winning essay and twenty-one others are published in the present volume. It affords an opportunity of obtaining a rather clear understanding of this interesting mathematical concept, since each essayist has approached the subject from his own viewpoint and has made his discussion as simple and clear as possible. In the introduction Professor Manning gives a historical sketch of the work that has been done in the field of n dimensions, and furnishes a list of books and articles which treat of the fourth dimension.

Every teacher will find this an interesting and profitable book to have at hand. It should be in every high school library since this problem of the fourth dimension has attracted the attention of many boys and has often led to a deepened interest in mathematics. H. E. C.

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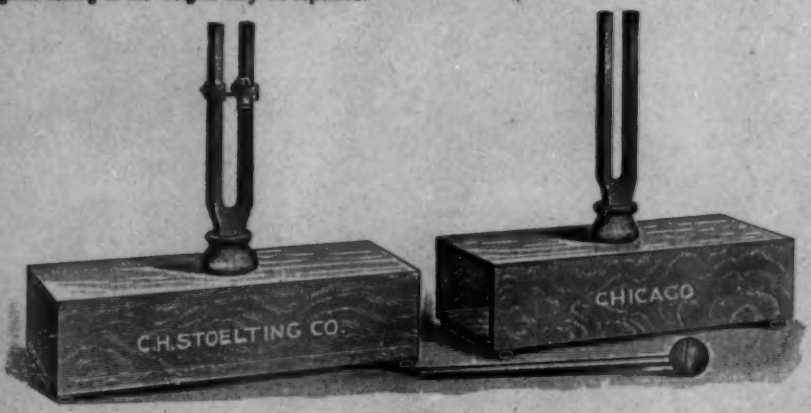

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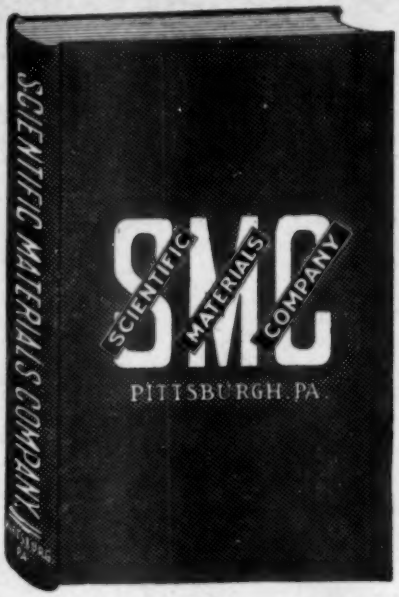

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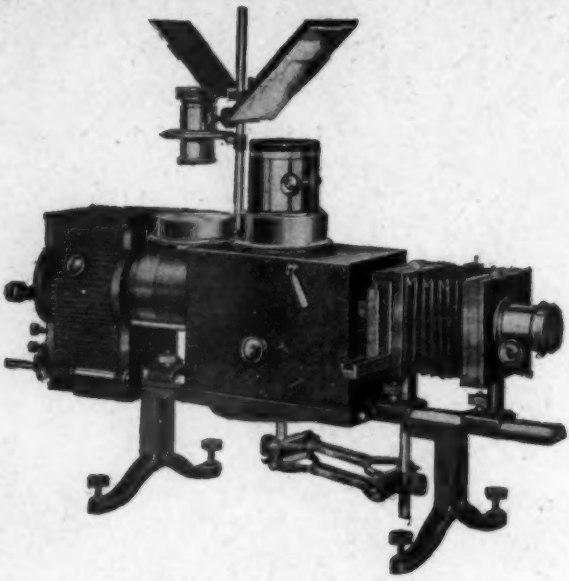

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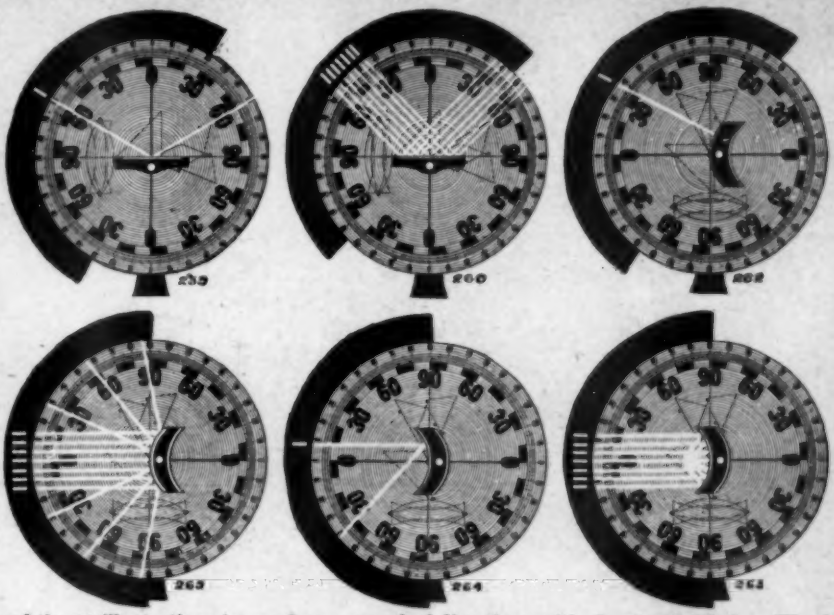

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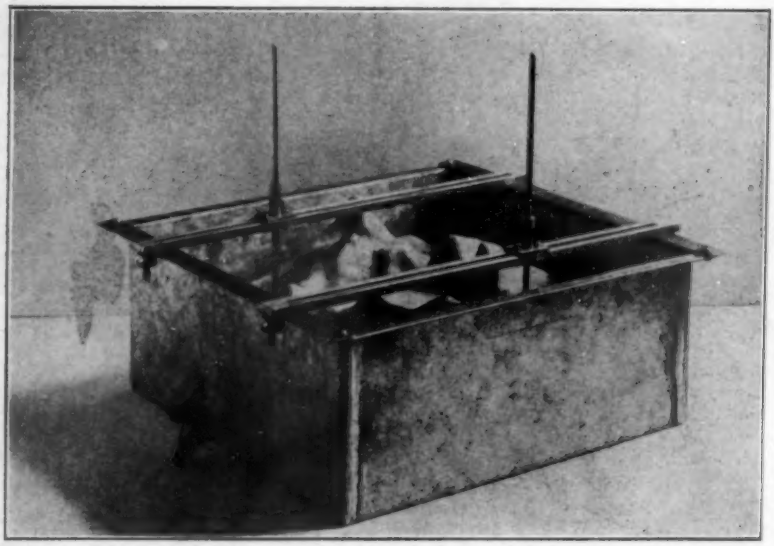

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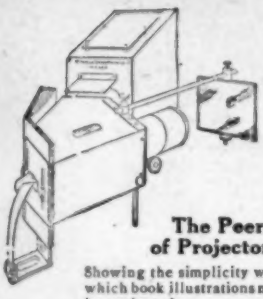

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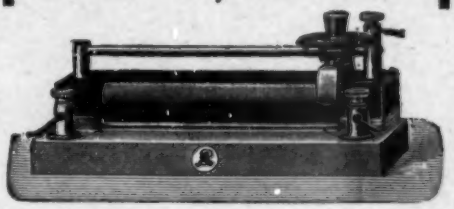

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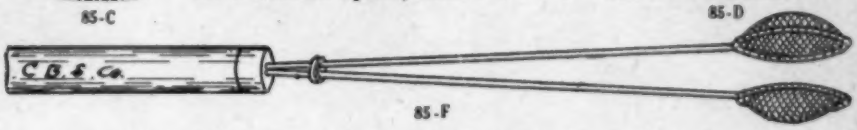

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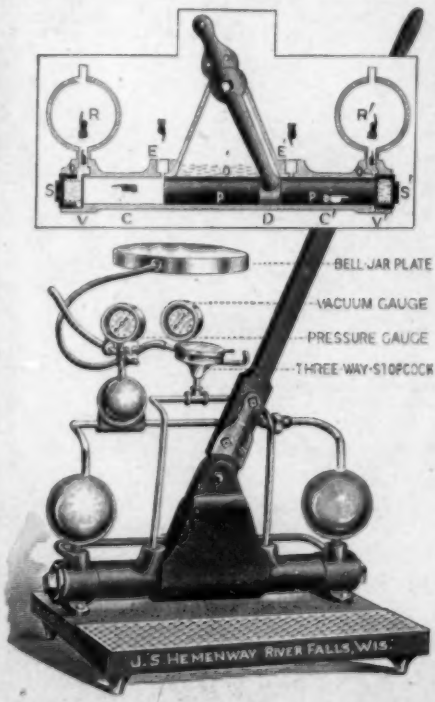

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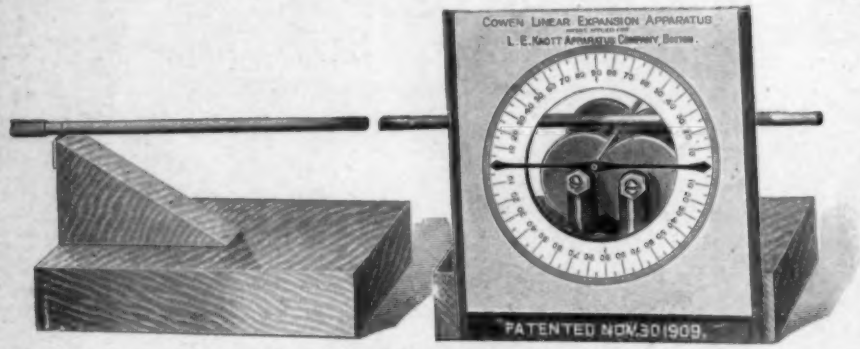

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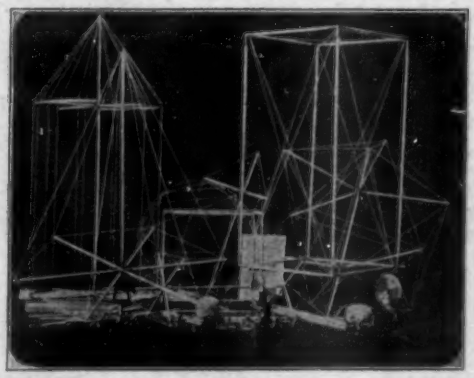

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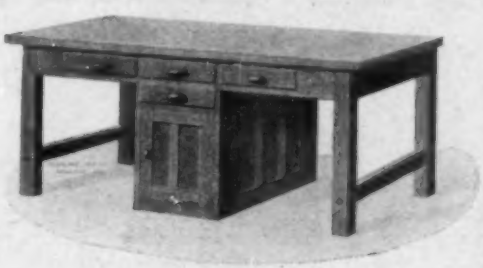

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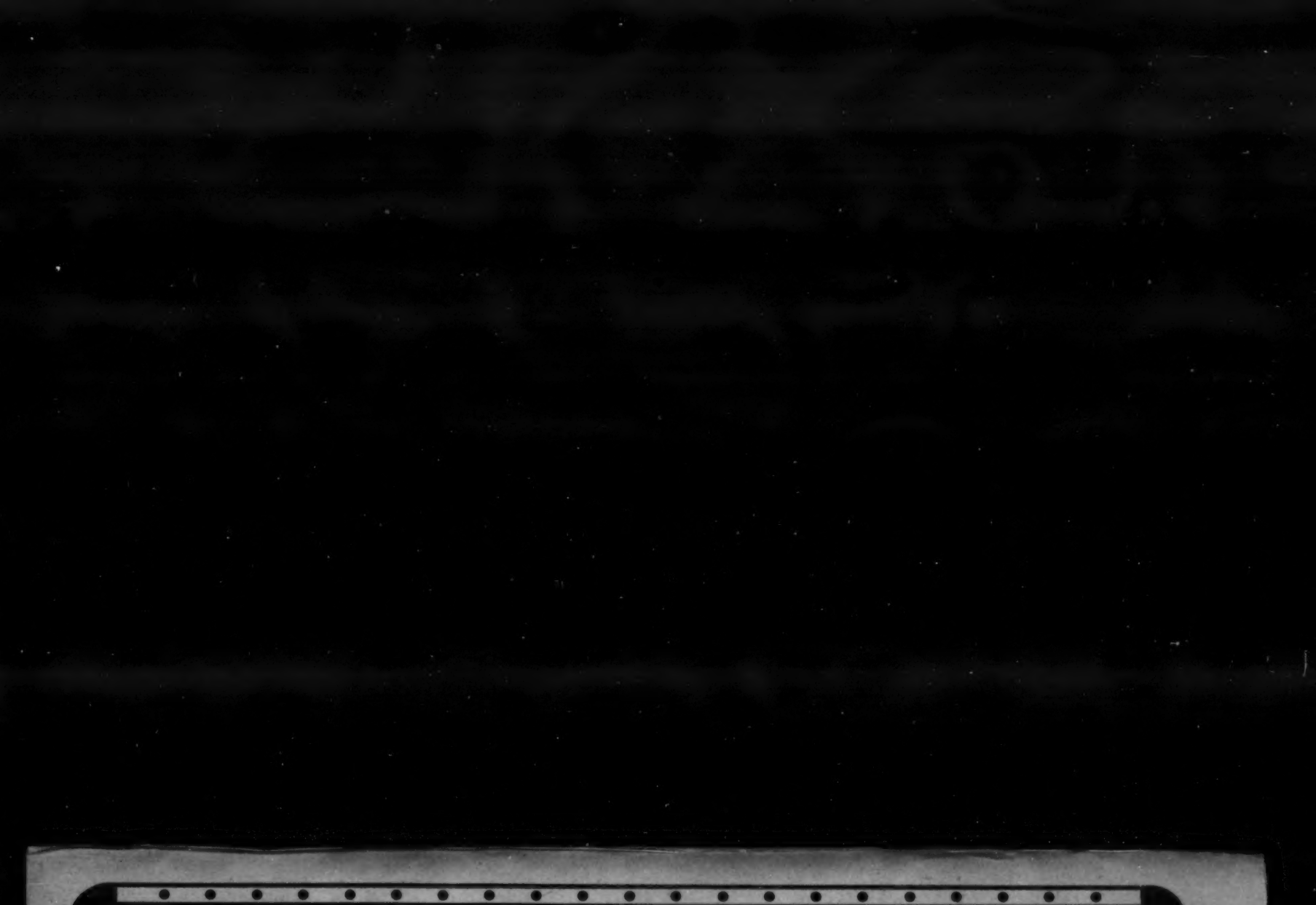
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